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Trends in Maternal and Infant Health:

An Analysis of Births in Montgomery County, Ohio, 2000-2010

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Abstract

The demographic characteristics of women who give birth are continually changing. Age, education, use of assisted reproductive technology, BMI before pregnancy, and weight gain during pregnancy are maternal factors that play a role in maternal and fetal health. Other factors including induction, route of delivery, calculated gestational age, and birthweight help determine and identify complications of pregnancy. The purpose of this study is to analyze trends of maternal demographics, risk factors, and birth outcomes associated with poor health outcomes. This research is a secondary analysis of Ohio Natality Statistical Files collected by the Ohio Department of Health, Center for Vital and Health Statistics. From this file, the study analyzed data of women who are residents of Montgomery County. Trends of maternal age, education, body mass index, infertility use, gestational weight gain, induction rates, C-section delivery rates, gestational age, and birthweight were examined. Chi-square calculations were conducted to test trend significance ($P\text{-value} < .001$). Significant trends this study examined were increases in overall induction rates (37%) and overall C-section rates (57%), and a decrease in non-induced women delivering vaginally (29%). As social norms and technology change, so do the factors that affect maternal and infant health. Results of this study will provide data to help assess what future interventions are needed to promote maternal and infant health. Such interventions could include preconception education, education on obstetric processes and their associated risks, and medical retraining.

Keywords: maternal and infant health, maternal demographics, birth procedures, birth outcomes

Demographic Changes in Maternal and Infant Health: An Analysis among Montgomery County Residents from 2000-2010

As the world has changed in numerous ways, so have the factors that play a role in pregnancy. Pre-pregnancy planning, pregnancy, and birth rates have continually been affected by ever-changing social norms, quality and access of health care, and technology. Social norms that have driven change include women's roles in society, education levels, and age at first marriage. In the early 1900s it was not uncommon to marry at a very young age and immediately start a family. As the times changed and women started to develop a more prominent role within society, many have furthered their educational attainment. In 1975, the United States Census Bureau recorded the percentage of women who finish high school and the percentage who had earned a bachelor's degree as 62% and 11%, respectively (Day & Newburger, 2002). Over the next 25 years, a dramatic increase in both categories was seen. In 2000, 85% of women attained a high school diploma and 24% of women went on to earn a bachelor's degree. Another striking trend in the United States is the age at first marriage. For decades, the average age at first marriage has steadily climbed; from 20.3 years of age in 1970 to 25.6 years in 2007 (Jaysen, 2008). As women continue to close the gender gap of educational attainment and professional careers, many delay starting a family and childbirth. For example, in the 1970s the average age for a woman to have her first child was 21.4 years (Mathews & Hamilton, 2009). In 2006, the average age for first-time mothers was 25.0 years, a 3.6 year increase from 1970 to 2006. Along with these changes in social norms came even greater technological change, affecting pregnancies in both positive and negative ways.

The unprecedented changes in advancing technology and innovation drastically improved medical resources, medical information systems, and available treatment options. Assisted

reproductive technology (ART) is no exception. Since 1981, women in the United States have used ART to help them become pregnant (Centers for Disease and Prevention [CDC], 2011b). Advanced technology following the inception of ART has led to numerous and improved procedural methods that increased success rates. The Assisted Reproductive Technology Success Rates: National Summary and Fertility Clinics published by the CDC reported that live birth rates resulting from use of ART were two times higher in 2008 than in 1999. This same study reported that the average age for women using ART was 36 years. In 2008, women between the ages of 35 and 40 years made up about 41% of all women using these technologies, while those 41 and older represented an additional 21%. Though there is limited success, ART has made it more likely for women with advancing maternal age to become pregnant and have a live birth. In 1970, only about 1 in 100 first births were to women 35 years of age or older compared in 2006, wherein nearly 1 in 12 first births were to women 35 years or older; a proportion that increased by 8 times (Mathews & Hamilton, 2009). Technology advances and all of the perks that come with this social norm shift have set the stage for increasing trends in the number of women with advancing maternal age.

Though the technology age has created vast improvements in health care, it has also made contributions to the diminishing health of a large portion of the population. Since the mid-1980s, obesity rates among the adult population have continued to rise in the United States; today, one in three adults is obese (CDC, 2011a). Obesity is a very complex problem which is enhanced by changes in our environment. Technology changes are only one facet of this problem, but remain a key player in this epidemic. For example, technology has allowed the food industry to create and distribute more processed foods with lowered nutritional values. Also, technology influences a more sedentary life style; people sit in front of screens for work

and leisure. Consequently, more women than ever are entering pregnancy overweight and obese, which can affect maternal and infant health.

As our environment changes and evolves, so do the demographics of women becoming pregnant and giving birth. Age, education, use of fertility treatments, body mass index (BMI) before pregnancy, and weight gain during pregnancy are factors that play a role in maternal and fetal health. Other factors including induction, route of delivery, and calculated gestational age and birthweight help to determine or identify complications of the pregnancy. The trends of these factors need to be monitored in order to help researchers evaluate and determine specific interventions that would help promote optimal maternal and infant health.

Statement of Purpose

The purpose of this study is to examine changes in maternal demographics for Montgomery County, Ohio. Additionally, this study will look at birthing procedures and outcomes. In order to monitor trends, birth certificate data for an eleven year span (2000-2010) will be evaluated.

This project aims to answer the following research questions:

1. How have maternal factors such as age (from 2000-2010) and education, BMI rates, infertility use, and gestational weight gain (from 2006-2010) changed in Montgomery County and how do these compare to overall trends in the United States?
2. How have birthing procedures such as induction rates (from 2000-2010) and route of delivery (from 2006-2010) changed in Montgomery County and how do these compare to overall trends in the United States?
3. How have infant outcomes such as calculated gestational age and birthweight changed in Montgomery County from 2000-2010 and how do these compare to overall trends in the United States?

Literature Review

A mother plays a vital role for the human race. In addition to contributing half of her offspring's genes, she also provides an initial environment for growth for a period of nearly 40 weeks. Many of a child's health outcomes are dependent on the quality of this environment. Maternal and fetal health persists at the forefront of public health, and much effort is expended in this area. For this reason, interventions and pregnancy guidelines continue to change in order to encompass recommendations for the different populations of women entering fertility. It is essential to research trends in maternal factors and delivery outcomes for the basis of interventions that promote maternal and infant health.

Maternal Age

One growing subpopulation that interventions and pregnancy guidelines need to take into consideration is women who become pregnant at an older age. In recent decades, social norms have shifted, encouraging women to delay childbearing well into their thirties, and even after the age of 40 (Jahromi & Hussein, 2009). In the United States, the number of women between ages 35 and 39 giving birth increased 36% from 1991 to 2001. There was also a remarkable shift in women ages 40 to 44 giving birth, a 70% increase (Heffner, 2004). Due to the introduction of assisted reproductive technology, it is expected that the number of women with advanced maternal age will continue to increase.

Age plays a strong role in a large array of birth outcomes such as birthweight, plurality, and various birth defects (Mathews & Hamilton, 2009). Though advancing maternal age has become a new norm, obstetricians consider it to be a risk factor because of the potential for complications to arise in both the mother and her fetus. For example, it is more common for these women to have higher rates of chronic disease than younger women. Entering pregnancy

with chronic disease puts a woman at risk for complications during gestation and possibly post-pregnancy (Rasmussen, Catalano, & Yaktine, 2009). Another study by Jahromi and Hussein (2008) found that advancing maternal age, defined as 40 years and older, was associated with a significantly higher incidence of complications. These complications included gestational hypertension, diabetes, preeclampsia, placental abruption, delivery via Cesarean section, and preterm birth. The study also found a correlation between advancing maternal age and a low birthweight. Furthermore, as women age the quality of the ova can deteriorate (Heffner, 2004). This deterioration is thought to contribute to the fertility decline and increasing risk for chromosomal abnormalities. Though childbearing can be delayed into the fourth, fifth, and even sixth decade of life, health risks become drastically more prevalent.

Maternal Weight

Historically, concern was placed on underweight women and maternal and infant health outcomes; however, the nation has seen a dramatic increase in the percentage of the population who are overweight or obese (Kirmeyer & Rubertone, 2008; CDC, 2011a). Commonly, body fat is measured indirectly by using (BMI) calculations which are based on the weight and height of an individual (Ogden et al., 2006). According to the CDC, adult weight status is divided into four categories; underweight, normal weight, overweight, and obese. Adults are considered to be underweight when their BMI falls below 18.5, normal weight if their BMI falls between 18.5 and 24.9, overweight if their BMI is between 25.0 and 29.9, and obese if their BMI is 30 or above (CDC, 2011a). The World Health Organization (WHO) breaks adult weight statuses down even further, by sub-categorizing obesity into classes. Obese adults with BMIs falling between 30.0 and 34.9 are defined as class I, class II when their BMI is between 35 and 39.9, and class III when their BMI is 40 or above (World Health Organization [WHO], 2012). Since the mid-1980s

the ever increasing trend of obesity in adults began and has gradually increased across the United States (Demont-Heinrich, Hanson, McCulloch, & Archer, 2009). By using data collected from the National Health and Nutritional Examination Survey (NHANES), the United States Health and Human Services saw an increase in the percentage of overweight or obese individuals, from 56% from data collected between 1988 and 1994 to 64% from data collected between 1999 and 2000 (National Health and Nutrition Examination Survey, 2003).

This increasing trend in weight gain is also true for women of reproductive age, ages 18-45. Data collected during 2004 and 2005 showed that nearly 15% of women between the ages of 25 and 34 were obese (Athukorla, Rumbold, Wilson, & Crowther, 2010). In 2006, 18 states incorporated collection of maternal height and weight in birth certificate data. Using this information to calculate BMIs, one study found that of the 1.4 million women who gave singleton births in 2006, nearly half were considered overweight or obese (Kirmeyer & Rubertone, 2008). Maternal overweight and obesity can often lead to more frequent obstetric care, and thus trends need to be analyzed for future health care planning.

Pre-pregnancy obesity is risky for both the mother and her infant (Cnattingius, Berstrom, Lipworth, & Kramer, 1998). It is associated with a number of complications which include gestational diabetes and hypertension, Cesarean section, and fetal death (Kim, Dietz, England, Morrow, & Callaghan, 2007). Obese women are three times more likely to develop gestational diabetes and two times more likely to develop gestational hypertension than normal weight women (Kirmeyer & Rubertone, 2008). Furthermore, overweight and obese mothers are more likely to have labor induced and need a C-section than normal weight mothers (Athukorala et al., 2010). Pregnant woman who are obese tend to have longer gestation periods which can increase the chances of post-term delivery. Maternal complications and perinatal morbidity and mortality

increase as pregnancy extends beyond term, contributing to the increasing trend of induction of labor (Arrowsmith, Wray, & Quenby, 2011). Additionally, overweight and obese women are more likely to gain more than the recommended amount of weight during pregnancy, creating more risk for adverse health outcomes (Dodd et al., 2011). Pre-pregnancy obesity also poses long-term risks. For example, children born to obese mothers are two times more likely to become obese and develop type 2 diabetes later in life.

Gestational Weight Gain

Gestational weight gain is another maternal factor that determines health and birth outcomes; however recommendations have varied over the years. The guidelines for gestational weight gain published in 1990 by the Institute of Medicine (IOM) focused on minimizing low birthweight babies and preterm births (Rasmussen et al., 2009). In the last two decades, a growing body of evidence has helped identify consequences for maternal and infant health due to inadequate or excessive weight gain during pregnancy. In 2009, the IOM and the National Research Council (NRC) released *Weight Gain During Pregnancy: Reexamining the Guidelines*. Through extensive studies, this review examined both short and long term health outcomes and evaluated tradeoffs associated with weight gain. For each BMI category, the committee recommended weight ranges for which the tradeoffs were most favorable. The review suggests that underweight women gain 28-40 pounds, normal weight women gain 25-35 pounds, overweight women gain 15-25 pounds, and obese women gain 11-20 pounds (Bureau of Health Informatics, 2011). Unfortunately, the guidelines are lacking for certain subpopulations; there was not enough data recorded to suggest ranges for pregnant adolescents, women who were carrying multiple fetuses, underweight women carrying twins, or class II and III obese women (Fernandez, Hoffmire, & Olson, 2011). As women of childbearing age shift into these

categories, recommendations need to be available which help promote overall healthiness for the mother and her baby.

A large body of research has found that 30 to 40% of women gain above or below the IOM recommendations (Stotland et al., 2005; Frischknecht, Bruhwiler, Raio, Luscher, 2009). More specifically, underweight women tend to gain below the guidelines whereas overweight women gain above them. One cohort study of women by Stotland et al. (2005) examined target weight gain of women, which has been strongly associated with actual weight gain. They found that of normal weight women, only 4.3% reported their target weight gain to be higher than the IOM recommendations compared to 24.1% of overweight women. Of those women categorized as underweight, 51.2% reported target weight gain below the guidelines while only 10.4% of normal weight women reported low weight gain targets. Maintaining a healthy weight both before and during pregnancy can vastly lower risk factors for maternal and infant health.

The health of a mother and her fetus can be assessed by the amount of weight she gains during pregnancy (Addo, 2010). Gaining too much or too little can be cause for alarm because of the increased risk for complications (Helms, Coulson, & Galvin, 2006). One study by Addo (2010) found that women who had insufficient weight gain during pregnancy were more likely to have restricted intra-uterine growth, preterm delivery, and low birthweight babies. On the other hand, women who had excessive weight gain were more likely to have large-for-gestational-age infants, need a Cesarean section, and retain weight after giving birth (Rasmussen et al., 2009). Women who consume nutritional foods, exercise, and gain within the recommended weight range are promoting favorable health outcomes for mother and baby.

Plurality

Since the 1980s, birth plurality, or when a single pregnancy results in multiple births, across the United States has continued to rise. One study by Martin and Park (1999) found that from 1980 to 1997 twin births increased 52%. The same study also found that pregnancies resulting in triplets and other higher multiple births rose 404% during this period. Twin birth rates hit an all-time high in 2009, reaching 33.2 births per 1,000 total births; an increase of 47% since 1990 (Martin et al., 2011). Higher order multiple birth rates peaked in 1998, reaching 193.5 per 100,000 total births. Since this peak, the rate has continued to fluctuate but has a general downward trend. As evidenced by the growing body of research, twin birth rates and other higher order birth rates have increased at an unprecedented speed over the past three decades, particularly during the 1980s and 1990s.

The increase in birth plurality has been associated with a number of factors. One such factor that research has shown to be associated with plurality is advancing maternal age (Ooki, 2011). Across the United States, we have seen an increase in the number of mothers with advancing maternal age, likely contributing to the climbing birth rates of twin and higher order multiple births (Martin et al., 2011). Another factor that could play a role is fertility therapies. Technology has made these treatments, such as ART, widely available.

Though fertility treatments assist women to become pregnant, especially older women, pregnancies with multiple fetuses are riskier than singleton pregnancies. Birth plurality can increase the risk of complications during pregnancy and the birthing process (Australian Institute of Health and Welfare [AIHW], 2005). For example, women carrying multiple fetuses are more likely to need a C-section. Additionally, plural births typically result in lower birthweight babies. Of twin births and triplet births in 2009, 10% and 35%, respectively, were born with

very low birthweight (VLBW), defined as less than 1,500 grams (Martin et al., 2011).

Comparatively, only 1% of singleton births fell into this category. Plurality has also been associated with increased risk for perinatal mortality and morbidity; within the first month of life, smaller size multiples are eight times more likely to die (AIHW, 2005; Martin et al., 2011).

Induction Rates

Labor induction during pregnancy is a procedural method of stimulating uterine contractions before labor begins naturally (Martin, Kirmeyer, Osterman, & Sheperd, 2009b; Mayo Clinic Staff, 2011). Over the past two decades, this practice has become more common, evidenced by research documenting an increase in induction rates (Caughey et al., 2009). While some doctors induce labor to prevent complications associated with maternal and infant risk factors (Hussain, Yakoob, Imdad, & Bhutta, 2011), convenience and control have recently begun to contribute to the increasing trend. The National Center for Health Statistics reported that induction rates have increased 125% from 1989 to 2001 (Simpson & Atterbury, 2003). Another study by the CDC found that from 1990 to 2006 induction rates increased from 10 to 22% (Martin et al., 2009a). In many cases, labor is induced for nonmedical reasons; elective induction is growing at a faster rate than induction as a whole (Caughey et al., 2009). Some studies suggest that there may be an over medicalization of childbirth, instead of letting nature take its course.

Electing to induce labor can put women and infants, who are otherwise healthy, at unnecessary risks. Babies born before their due date electively are at much higher risk of costly, long term health problems (Donovan, Iams, & Rose, 2008). Inducing labor can also increase the chances of needing a Cesarean section, which is associated with a host of health risks. Current studies have shown that those women who elect to have labor induced are more likely to be

white, well-educated, married, have health insurance, and receive early and continuous prenatal care with no medical complications (Simpson & Atterbury, 2003).

Cesarean Section Deliveries

In the United States, Cesarean sections account for nearly 31% of all deliveries (O'Callaghan, 2010). Each year, more than 1.3 million Cesarean sections are performed, making it the most common major medical surgery for women today (MacDorman, Menacker, & Declercq, 2008). Speculations have been made as to why this number has reached an all-time high. Advancing maternal age, fertility treatment usage, multiple births, obesity, and defensive medicine are among those factors thought to contribute to this increase (Niino, 2011).

Though it is a seemingly common surgery, many adverse health effects are associated with Cesarean section deliveries (Nicholson, Cronholm, Kellar, Stenson, & Macones, 2009). These effects include an increase in length of hospital stay for both the mother and the baby, admittance into the neonatal intensive care unit, and maternal death. With rising trends and C-section rates reaching an all-time high, red flags have been raised in public health. Though some hospitals are testing intervention methods to decrease or reverse this rate, it will continue to be important to identify local, regional, and national trends.

Gestational Age and Birthweight

Gestational age, often associated with birthweight, is an important predictor of infant health. It is widely known that human gestation is approximately nine months long; however, in the medical field it is more common to measure pregnancy in weeks starting from the mother's last menstrual cycle (Donovan et al., 2008). Gestational periods include preterm, early preterm, late preterm, early term, full term, and post term. Preterm birth is defined as birth before 37 weeks of gestation; this is often broken down into early preterm (birth before 34 weeks) and late

preterm (birth between 34-36 weeks) (Martin et al., 2011). Additionally, early term, full term, and post term births are defined as birth between 37 and 38 weeks, 39 and 41 weeks, and after 41 weeks, respectively. A growing body of research has turned focus toward gestational age, as it acts as a dependable forecaster of infant health and the increase in preterm births during the second half of the twentieth century proved to be a striking public health concern.

In contrast to the increasing trend seen before the peak in 2006, recent preterm birth rates have declined consistently from 2006 to 2010. From 1981 to 2006, preterm birth rates rose nearly 35% with late preterm births contributing to much of this increase (Donovan et al., 2008; Martin et al., 2011). The 2010 preliminary birth results, conducted by the National Center for Health Statistics, reported a four year decline in overall preterm birth rates. Following the peak in 2006 of 12.80% of births, preterm birth rates were down to 11.99% in 2010; again, to the credit of a decline in late preterm births (Hamilton, Martin, & Ventura, 2011). Since 2006, late preterm births have fallen nearly 7% from the high of 9.14% to 8.49% of births. Some speculation has been made as to why preterm births increased consistently for nearly three decades. These reasons include an increase in elective induction of healthy women, C-section rates, and plural births (Martin et al., 2011). However, research has yet to confirm causes for the noteworthy downward trend over the last few years.

Research shows that the earlier the birth occurs in the gestational period, the greater the chances are of higher medical costs, long term disabilities, and most importantly death (Donovan et al., 2008). Those babies born preterm are more likely to have serious respiratory illnesses, suffer from brain injury, need intensive care, and be hospitalized for a longer period of time. Certain subpopulations are at higher risk of having preterm births. For example, the youngest and oldest mothers are more at risk for having a preterm birth than mothers 25 to 34 years of age.

Also, a mother carrying more than one fetus is at higher risk for preterm delivery than a mother with a singleton birth. For healthy women, postponing delivery can help lower risk of adverse health outcomes. For example, an additional week inside the womb is associated with a shorter hospital stay for the baby, lower costs, and lower risk of life-long morbidities (Davidoff et al., 2006). Furthermore, the risk of infant mortality decreases as the gestation approaches full term (Martin et al., 2011). Adverse outcomes associated with preterm birth acquire high medical costs. It has been estimated that preterm births cost the United States upwards of 26 billion dollars each year (Behrman & Butler, 2007). For these reasons, premature birth continues to be a public health concern.

Although weight gain and BMI measures continue to rise across the United States, birthweight continues to drop. In the National Vital Statistics Reports by Martin et al. (2011), birthweights are arranged into four categories; very low, low, normal, and high. Newborns are considered to have very low birthweight (VLBW) if weight is below 1,500 grams, low birthweight (LBW) if weight is under 2,500 grams, normal birthweight (NBW) if weight is between 2,500 and 4,000 grams, and high birthweight (HBW) if weight is greater than 4,000 grams (March of Dimes Foundation, 2008; Martin et al., 2011). Birthweights climbed steadily from the 1950s until 1990; most likely a response to the changing maternal demographics such as increased BMI before pregnancy and unspecific guidelines for gestational weight gain (Wang, 2010). However, studies show that over the past 20 years, the number of newborns weighing less than 3,500 grams has increased (Martin et al., 2011). From 1990 to 2006 the percentage of LBW babies rose 20%. On the other hand, from 1990 to 2009 the number of newborns weighing between 3,500 and 4,000 grams has decreased nearly 10%. The shift toward lower weight newborns is not fully understood but studies suggest that the trend could be associated with

shortened gestational age, plurality rate increase and obstetric intervention over the past 30 years (Donahue, Kleinman, Gillman & Oken, 2010; Martin et al., 2011).

Birthweight continues to be a public health concern as it is a reliable indicator for newborn health and survival (WHO, 2008). Both LBW and HBW babies are at risk for adverse health effects. For example, babies who have lower birthweights are at higher risk for morbidities including asphyxia after birth, jaundice, congenital malformation and even premature death (Mansour, Eissa, Nofal, Kharboush, & Reda, 2005). In the United States, LBW is the leading cause of neonatal death and the second leading cause of all infant mortality (Davidoff et al., 2006). Although VLBW babies account for 1.5% of all births in the United States, they make up more than 50% of all infant deaths. One study by Wei et al. (2003) found that both LBW and HBW babies are at an elevated risk for type 2 diabetes later in life causing a U-shaped relationship between birthweight and risk of disease. HBW babies are at higher risk for birth trauma and may cause more injury to the mother during delivery (Wang, 2010). A growing body of research has also shown a strong association between HBW and increased risk for childhood and adulthood cancers (Ross, 2006).

Up-to-date interventions and pregnancy guidelines are lacking; the IOM last published guidelines for gestational weight gain in 1990. In over two decades, much has changed. Characteristics of women becoming pregnant and giving birth have continued to shift throughout history. It is important that these trends be examined in order for guidelines to stay current, in turn promoting and improving health outcomes. Commonly known as the “Melting Pot”, America is very diverse; the subpopulations of women entering childbearing age are no exception. These women are more ethnically and racially diverse, have a wider age range than ever before, are more educated, heavier, have more chronic conditions prior to becoming

pregnant, and are carrying multiple fetuses more often (Rasmussen et al., 2009). Other factors including induction, route of delivery, calculated gestational age, and birthweight help to determine and identify complications of the pregnancy. The concentrations of these factors likely vary from region to region and from state to state. Therefore, it is important to monitor trend data which can help to identify specific subpopulations in need of intervention strategies to promote health. Additionally, trends in maternal demographics and characteristics may provide necessary information to create appropriate maternal and infant health guidelines.

Methods

This research is a secondary analysis of Ohio Natality Statistical Files collected by the Ohio Department of Health, Center for Vital and Health Statistics. This is compiled information retrieved from Certificates of Birth of all births occurring in Ohio. From this file, the study will analyze data of women who are residents of Montgomery County; protocol was preapproved by the Institutional Review Board at Wright State University and Public Health Dayton and Montgomery County. The way data collection was conducted changed drastically in 2006; however this project sought to capture the trend of multiple factors over an 11 year period. Only data which had consistent collection definitions over the 11 year span (2000-2010) could be used. Table 1 summarizes the different variables that this study will look at. This includes trends of maternal age, education, weight, use of infertility treatments, gestational weight gain, induction rates, C-section rates, calculated gestational age, and birthweight.

Table 1. *Summary of Data Variables, the Number of Files Used, and Exclusions made for Determining Trends in Maternal Demographics, Obstetric Procedures, and Infant Outcomes*

Parameter	Years	N	Number of Total Births	% of Usable Birth Data	Exclusions
Maternal Age (1st Time)	2000-2010	32394	32397	100.0	Files reporting either 1) Previous Live Birth Living 2) Previous Live Birth Dead 3) 99 in Maternal Age
Maternal Age (All Births)	2000-2010	79639	79794	99.8	Files containing a 99 in 1) Maternal Age
Maternal Weight Gain	2006-2010	34432	35459	97.1	Files containing 9, 99, or 999 in either 1) Pre-pregnancy Weight 2) Weight at Delivery 3) Maternal Height (feet) 4) Maternal Height (inches)
Maternal Education	2006-2010	35405	35459	99.8	Files containing a 9 in 1) Maternal Education
Maternal BMI	2006-2010	34977	35459	98.6	Files containing a 9, 99, 999 in 1) Maternal Height (feet) 2) Maternal Height (inches) 3) Pre-pregnancy Weight, respectively
Use of Infertility	2006-2010	28528	35459	80.5	Files containing U in 1) Infertility
Route of Delivery	2000-2010	79133	79794	99.2	Files containing 0 in 1) Route of Delivery
Induction	2000-2010	79730	79794	99.9	Files containing 9 in 1) Induction
Calculated Gestational Age	2000-2010	69072	79794	86.6	Files containing 9 in 1) Calculated gestation
Birthweight	2000-2010	79741	79794	99.9	Files containing 9999 in 1) Birthweight

Table 1 describes the time range for which data was collected on each variable, the number of births used to examine each variable (N), the number of total births during each time period, the percentage of the population used, and exclusion criteria for the data. For example, when examining the trend for maternal age at first birth, the collection included first time mothers. Out of the 79,794 birth files available from 2000 to 2010, those files reporting previous live births now living or previous live births now dead were excluded, leaving 32,397 files. From 32,397, those files containing a 99 in the maternal age section were excluded. Of the 32,397 potential files, 32,394 were actually used for data analysis. Furthermore, Table 2 defines the constitutive and operation definitions for each parameter examined in this study, as well as clearly defines the levels of measurement used.

When data collection changed in 2006, the way in which maternal educational attainment was reported and the inclusion of maternal height were among the improvements. Consequently, this study will examine the trend of maternal educational attainment for a five year period (2006-2010). In addition, using height and pre-pregnancy weight, maternal BMI will be calculated. The CDC defines BMI as shown in equation 1:

$$\text{BMI} = (\text{weight} / (\text{height}^2)) \times 703 \quad (1)$$

Where the product of weight (measured in pounds) and square height (measured in inches) is multiplied by a conversion factor of 703. This calculation will be used to track a five year trend of maternal BMIs in Montgomery County.

Table 2. *Summary of Data Variables Including Constitutive Definition, Operational Definitions, and Level of Measurement*

Parameter	Constitutive Definition	Operational Definition	Level of Measurement
Maternal Age	Mothers age at time of birth	Calculated from mothers reported date of birth	Categorical: 1 = <15 5 = 30-34 2 = 15-19 6 = 35-39 3 = 20-24 7 = ≥40 4 = 25-29
Maternal BMI	Mothers body mass index before pregnancy	Calculated using mothers pre-pregnancy weight (pounds) and height (inches) reported	Categorical: Underweight = <18.5 Normal = 18.5-24.9 Overweight = 25.0-29.09 Obese = ≥30
Gestational Weight Gain	The weight a mother gains during the gestational period	Calculated using the mothers pre-pregnancy weight (pounds) and the weight at the time of birth (pounds)	GWG Range by BMI: Underweight = 28-40 Normal = 25-35 Overweight = 15-25 Obese = 11-20
Induction	A method of stimulating uterine contractions before labor begins	Reported yes or no in birth certificate data	Categorical: Y = labor induction N = no labor induction
Route of Delivery	Delivery route that resulted in the birth of the baby	Reported at the time of birth	Categorical: 1 = vaginal 2 = vaginal after C-section 3 = primary C-section 4 = repeat C-section
Gestational Age	Length of pregnancy, measured in weeks, from the mothers last menstrual cycle	Calculated from the mothers last reported menstrual cycle and the date of birth	Categorical: Preterm = <37 Early Preterm = <34 Late Preterm = 34-36 Early Term = 37-38 Full Term = 39-41 Post Term = >41
Birthweight	Weight of the baby at birth, measured in grams	Reported at the time of birth	Categorical: VLBW = <1,500 LBW = <2,500 NBW = 2,500-4,000 HBW = >4,000

In addition to examining trends, the chi-square statistical test of association, χ^2 , will be performed. This statistic tests the association between row and column variables in the R-by-C table (where R is the row and C is the column) (Gerstman, 2008).

Table 3. *Generic R-by-C Table of Possible Test Parameters*

Parameter 1	Parameter 2			
	X ⁺	X ⁻	TOTAL	
	2000	A	B	A+B
	2010	C	D	C+D
		A+C	B+D	A+B+C+D

The independence of the variables in Table 3 is tested by this statistic when data are from naturalistic samples, such as birth certificate data. The chi-square statistic tests the null hypothesis, which assumes no association between the row and column variables in the source population. Pearson's chi-square test is defined in equation 2:

$$\chi^2 = \sum_{All} \left[\frac{(O_i - E_i)^2}{E_i} \right] \quad (2)$$

Where O_i represents the observed count in the table cell being examined and E_i is represents the expected count in the table cell, further defined in equation 3.

$$E_i = \frac{\text{row total} \times \text{column total}}{\text{table total}} \quad (3)$$

To find the P-value, which determines whether the chi-square value is significant, the χ^2 value and degrees of freedom are used. The definition for the degrees of freedom can be found in equation 4:

$$D_f = (R - 1) \times (C - 1) \quad (4)$$

Where R is the total number of rows in the table and C is the total number of columns in the table. In this study, chi-square calculations will be conducted to test if the trends from 2000 to 2010 are significant for subpopulations which 1) make up a large proportion of the study group and 2) have increased/decreased at least 25% over the study period.

Results

Maternal and infant health remains a public health concern around the world. However, changing factors which contribute to their health need to be monitored at local levels. This study evaluates 11 years of birth data (2000 to 2010) from Montgomery County, Ohio to track trends in maternal demographics, obstetric procedures, and infant outcomes which all help to determine maternal and infant health.

Figure 1 displays the distribution of the advancing maternal age at first birth. Between 2000 and 2010, there is notable decline in birth rates contributed by first time mothers between 15 and 19 years of age in Montgomery County, Ohio; a 15.3% decrease, dropping from 25.65% in 2000 to 21.71% in 2010. The percentage of mothers ranging from 25 to 29 years of age giving birth for the first time increased 14.3% from 2000 to 2010 (23.98% to 27.40%). Furthermore, first time births occurring from women 30 to 34 years of age have increased for the third consecutive year, from 11.72% in 2007 to 12.80% in 2010.

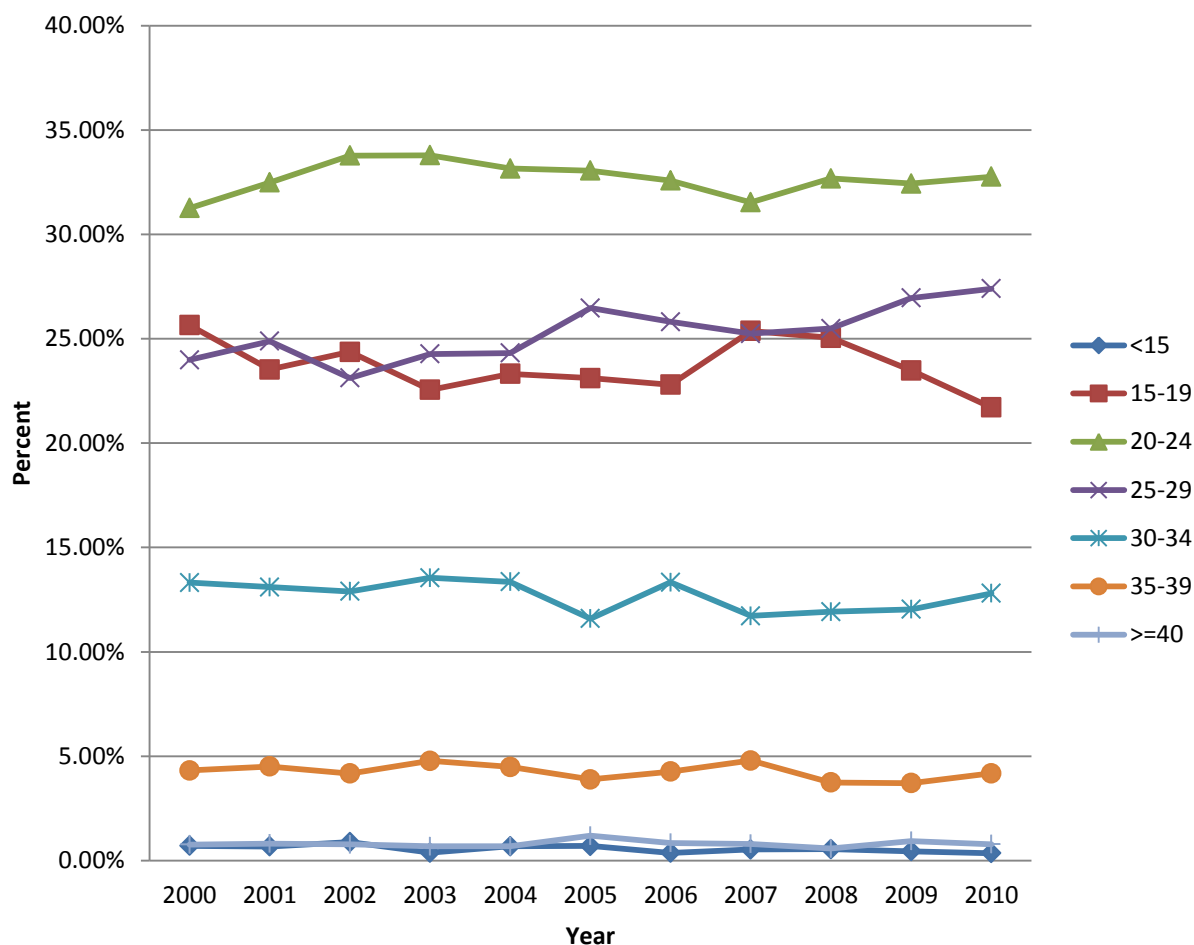


Figure 1. Percent of mothers in each age category at first birth in Montgomery County, Ohio from 2000 to 2010

In addition to looking at maternal age at first time birth, trends in maternal age for all births in Montgomery County from 2000 to 2010 are displayed in Figure 2. Maternal age trends have remained relatively constant over the eleven year study period. One notable trend is the women ranging from 25 to 29 years of age; increasing from 27.79% of all births in 2000 to 30.67% of all births in 2010. This is an overall increase of 10.4%. Again, the study shows a slight decline in the percentage of teenagers, 15 to 19 years of age, giving birth; nearly a 20% decline over the study period.

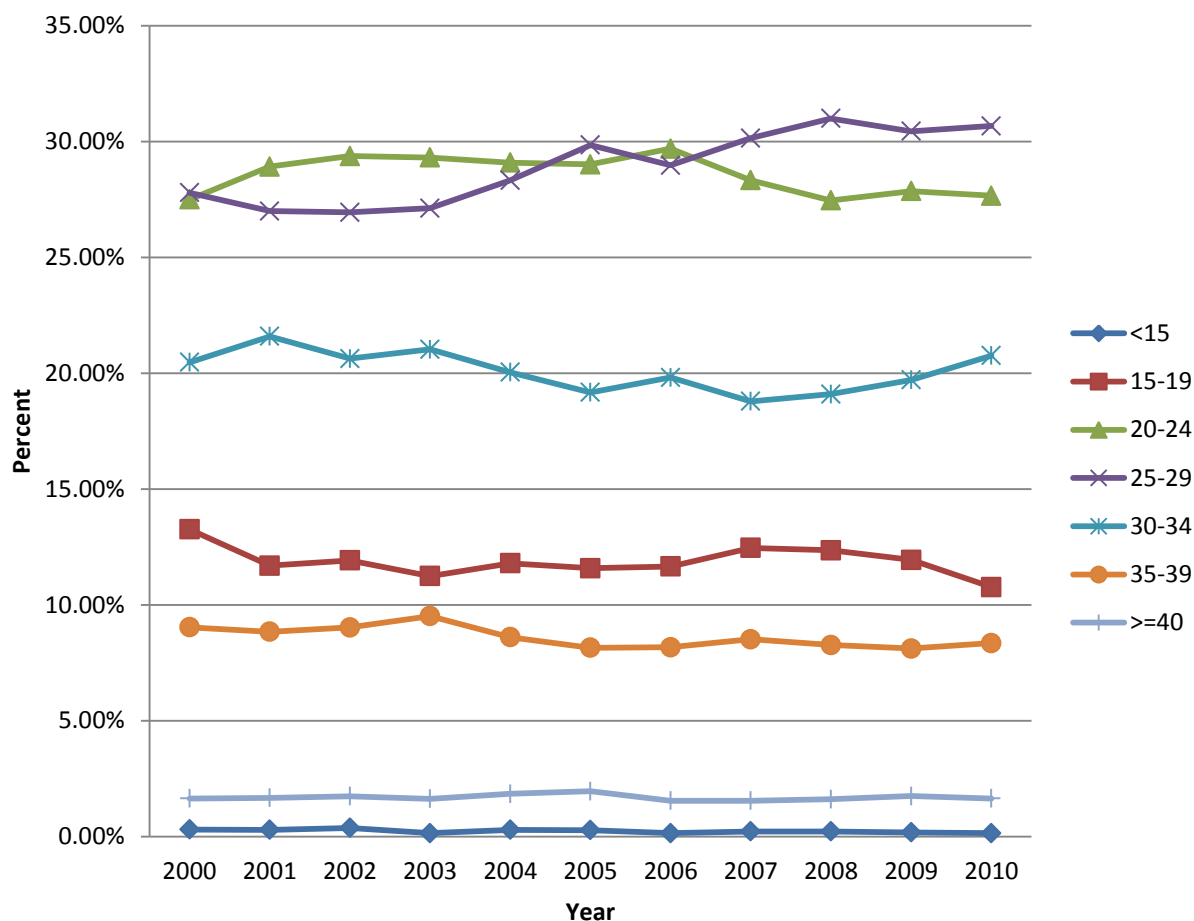


Figure 2. Percent of mothers in each age category that gave birth in Montgomery County, Ohio from 2000 to 2010

Due to changes in Birth Certificate data collection, maternal educational attainment could only be examined from 2006 to 2010, as shown in Figure 3. The rate of mothers attending high school, but not receiving a diploma decreased dramatically over this five year period. It was reported that in 2006, 17.57% of all mothers giving birth in Montgomery County only had some high school education. This rate dropped to 15.10% in 2010, an overall decline of 14%. On the other hand, women giving birth having attained either an associate's degree or master's degree has increased 16% and 18%, respectively. Additionally, the percentage women giving birth who

have obtained a doctorate degree or professional degree has slowly continued to climb from 2006 to 2010, increasing nearly 50% during these five years (1.12% to 1.66%).

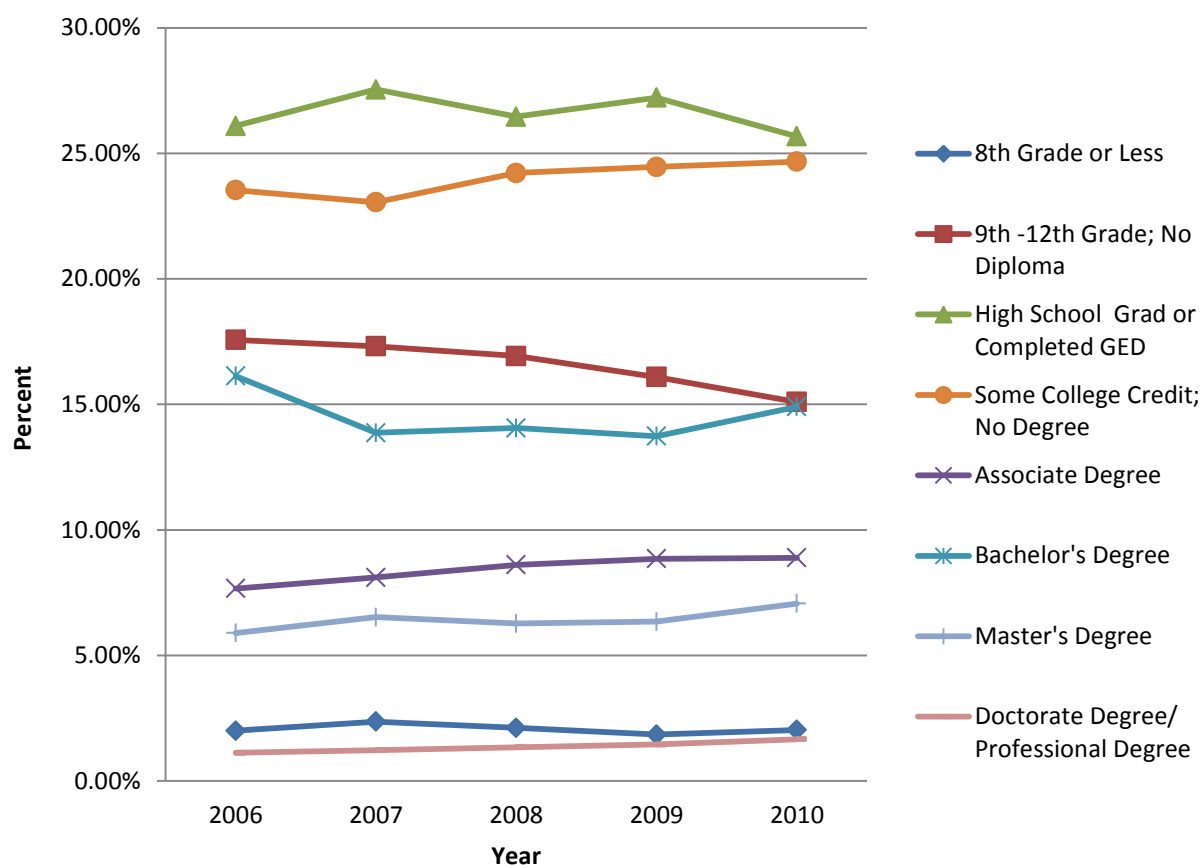


Figure 3. Percent of mothers that attained various education levels in Montgomery County, Ohio from 2006 to 2010

Though normal weight women with BMIs between 18.5 and 24.9, as defined by the CDC, account for the majority of mothers giving birth in Montgomery County, Ohio from 2006 to 2010, U.S. trends suggest that overweight and obese populations will soon be contributing more births nationwide. Figure 4 shows the distribution of the percentage of mothers giving birth in Montgomery County who fall into the four different BMI categories. Locally, we have seen a shift from overweight mothers to obese mothers. The percentage of mothers categorized

with pre-pregnancy obesity have increased to 25.62% of all births in 2010; a 9.8% rise from 2006.

The percentage of those mothers in Montgomery County categorized as underweight and normal weight have fluctuated, resulting in fairly constant trend from 2006 to 2010.

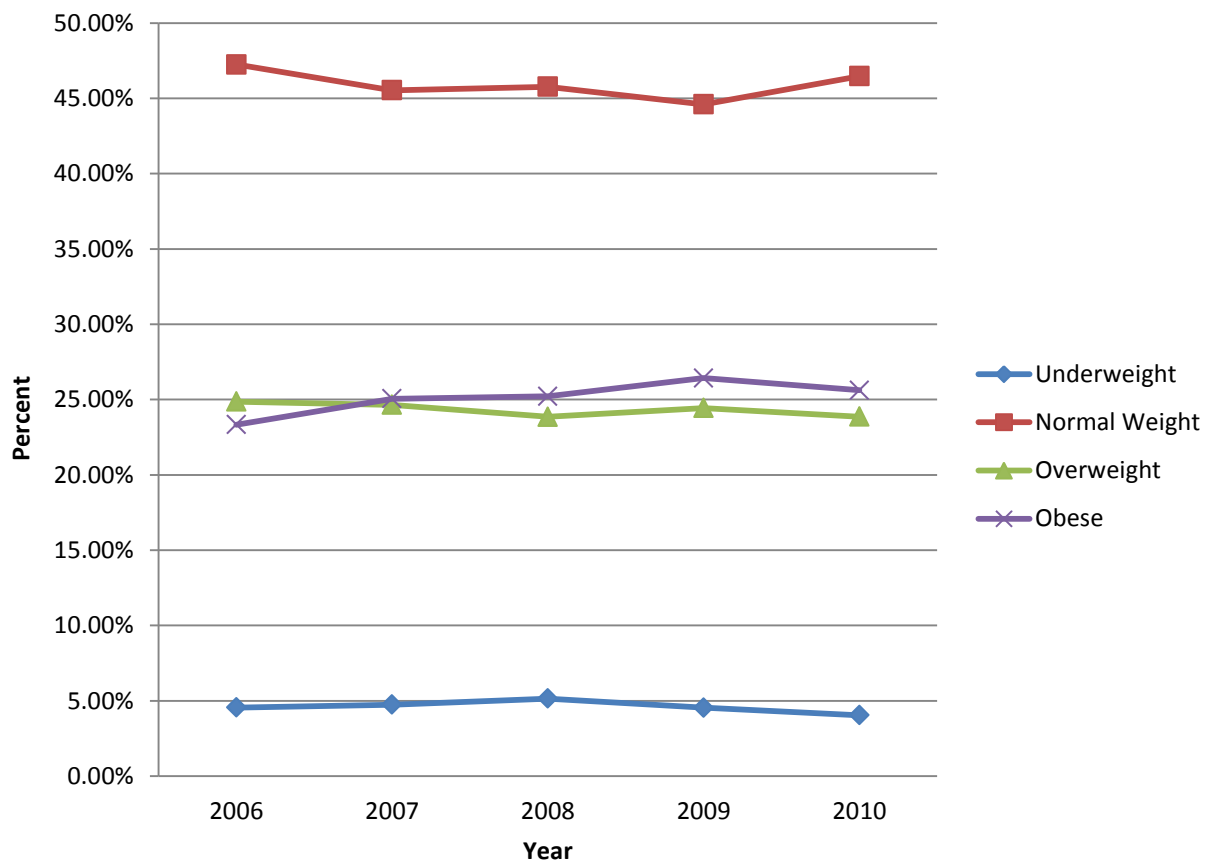


Figure 4. Percent of women in each pre-pregnancy BMI category that gave birth in Montgomery County, Ohio from 2006 to 2010

This study looked at overall infertility treatments used throughout Montgomery County, as shown in Figure 5. In 2006, birth certificate data began reporting use of infertility drugs or other assisted reproductive technologies. If the file reported use of either of these methods, the file should report utilization of infertility treatment. Although there is only a five year study

period, Figure 5 displays a two year increase of infertility treatment use. An increase from the low of 1.29% in 2008 to the high of 1.87% in 2010 resulted in an overall increase of 46.5%.

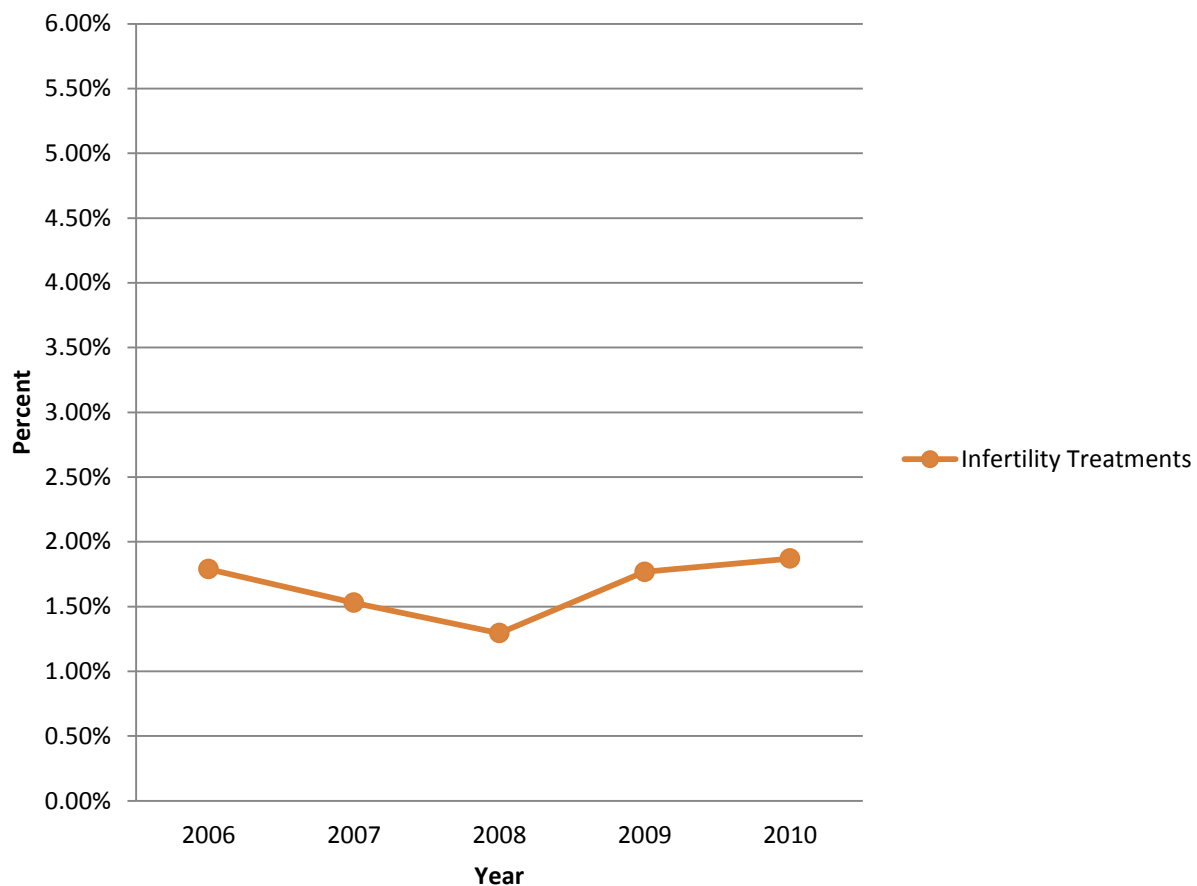


Figure 5. Percent of women that utilized infertility treatments out of all births in Montgomery County, Ohio from 2006 to 2010

Gestational weight gain (GWG) recommendations have changed over the years; however, the Institute of Medicine (IOM) most recently suggested recommendations of GWG ranges for each BMI category. By calculating BMIs and tracking weight gain during gestation for each birth file, trends of women in Montgomery County that fell below the recommendations, within the recommendations, and above the recommendations can be examined, as shown in Figure 6. All categories of GWG appear to remain constant over the study period; however the percentage of women who gain above the IOM recommendations is alarmingly high. Over the past five

years, more than 50% of the women giving birth in Montgomery County gained more than the recommended weight during gestation.

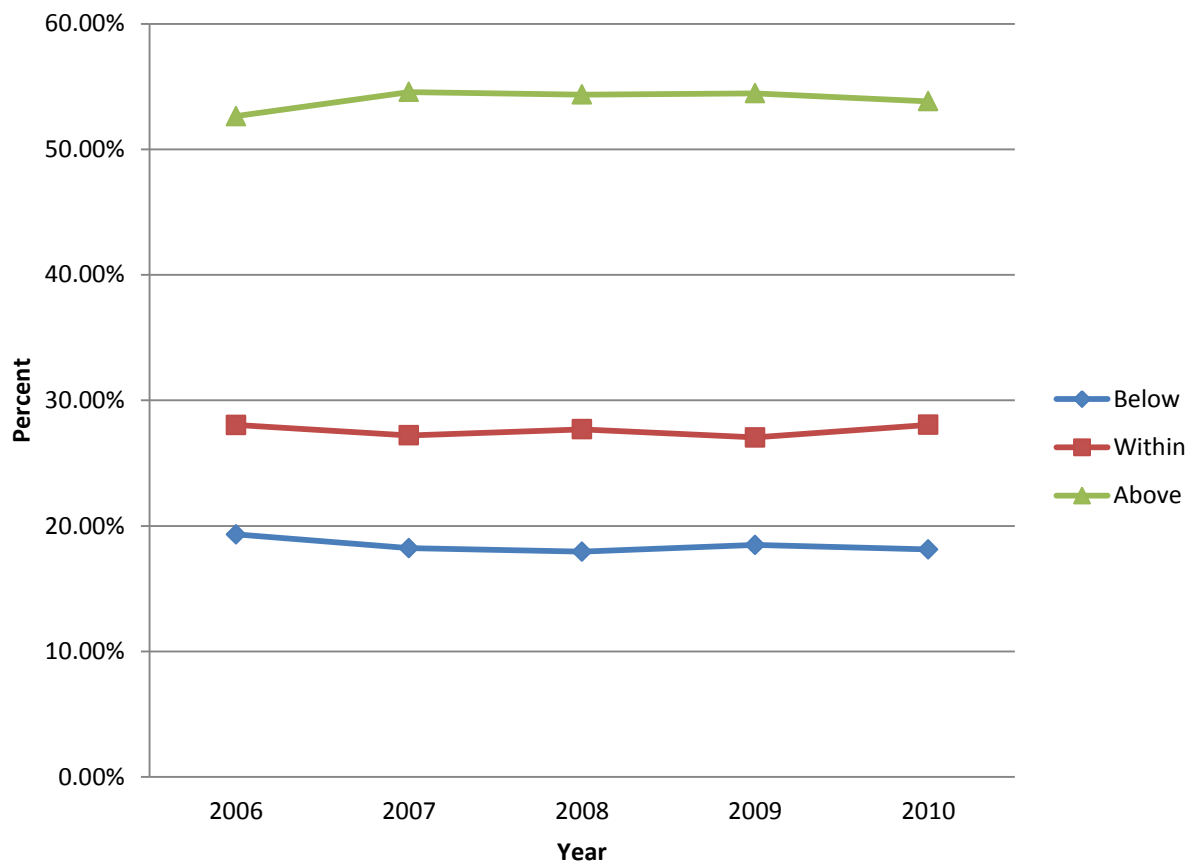


Figure 6. Percent of mothers that gained below, within, or above the IOM gestational weight gain recommendations in Montgomery County, Ohio from 2006 to 2010

Figure 7 shows the distribution of the percentage of women in Montgomery County who had labor induced compared to the percentage of women who did not have labor induced from 2000 to 2010. The percentage of all women in Montgomery County going into spontaneous labor over the past decade has decreased, while those women having labor induced continues to climb. We have seen a 12% drop, from 75.52% of all women going into labor naturally in 2000 to 66.37% in 2010. On the other hand, women having their labor induced increased from

24.48% of all women giving birth in Montgomery County in 2000 to 33.63% in 2010. Over this eleven year period, induction rates have climbed 37%, a significant (P-value < .001) increase.

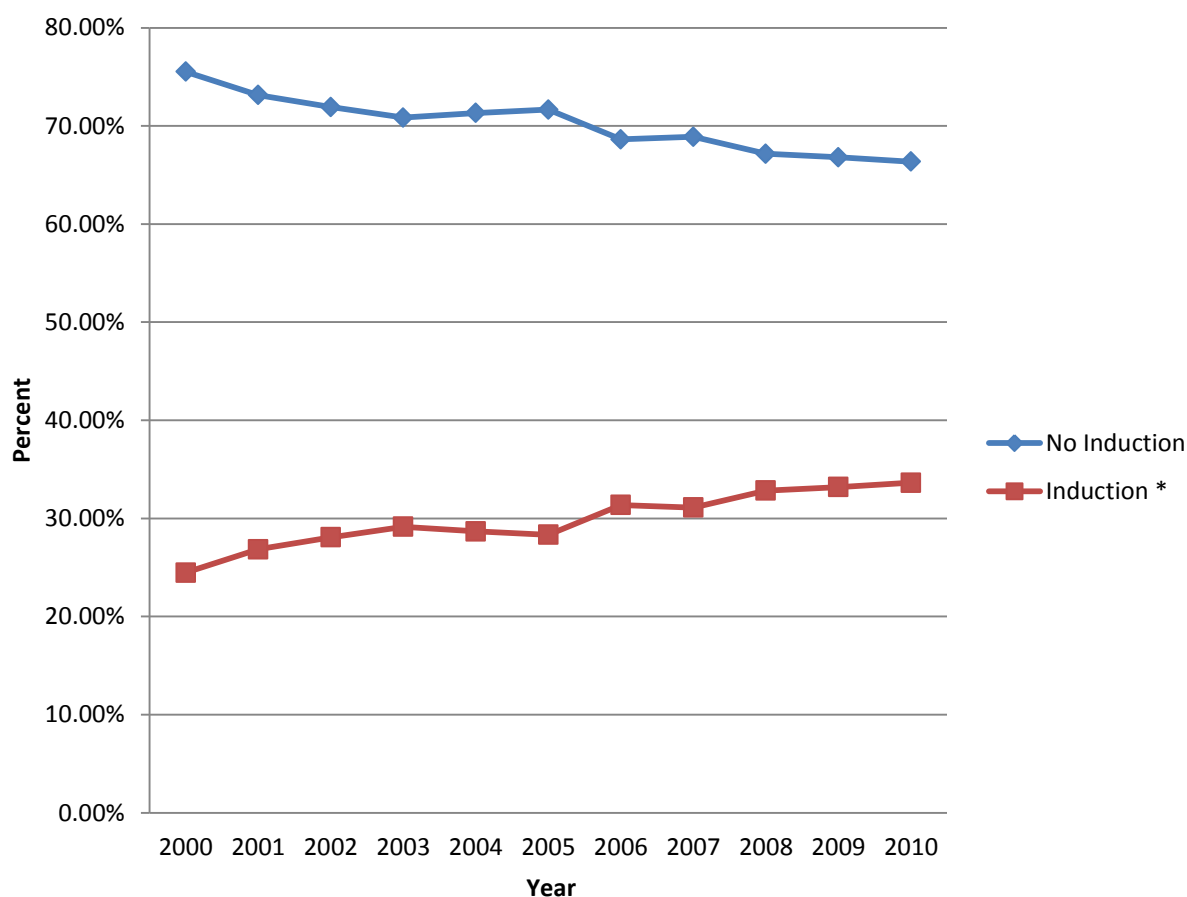


Figure 7. Labor induction rates for women in Montgomery County, Ohio from 2000 to 2010

Note: * represents trends that were tested for significance

Figure 8 shows the percentage of women that had labor induced by age category in Montgomery County from 2000 to 2010. While women between the ages of 20 and 34 make up a majority of women giving birth in Montgomery County, they too account for the majority of women having labor induced. As seen in the graph, while the percentage of women in their 20s having labor induced increased slightly over the 11 year period (ages 20-24 increased 11.6% and ages 25-29 increased 5.7%), the percentage of women in their 30s having labor induced decreased. Women aged between 30 and 34 years that had labor induced decreased 14.5% from

2000 to 2010 (23.22% to 19.86%) and those between 35 and 39 years of age decreased 24.3% during this time period (9.89% to 7.49%). Another notable trend would be the slight increase of the percentage of 15 to 19 year olds having labor induced, an overall rise of 8.8%.

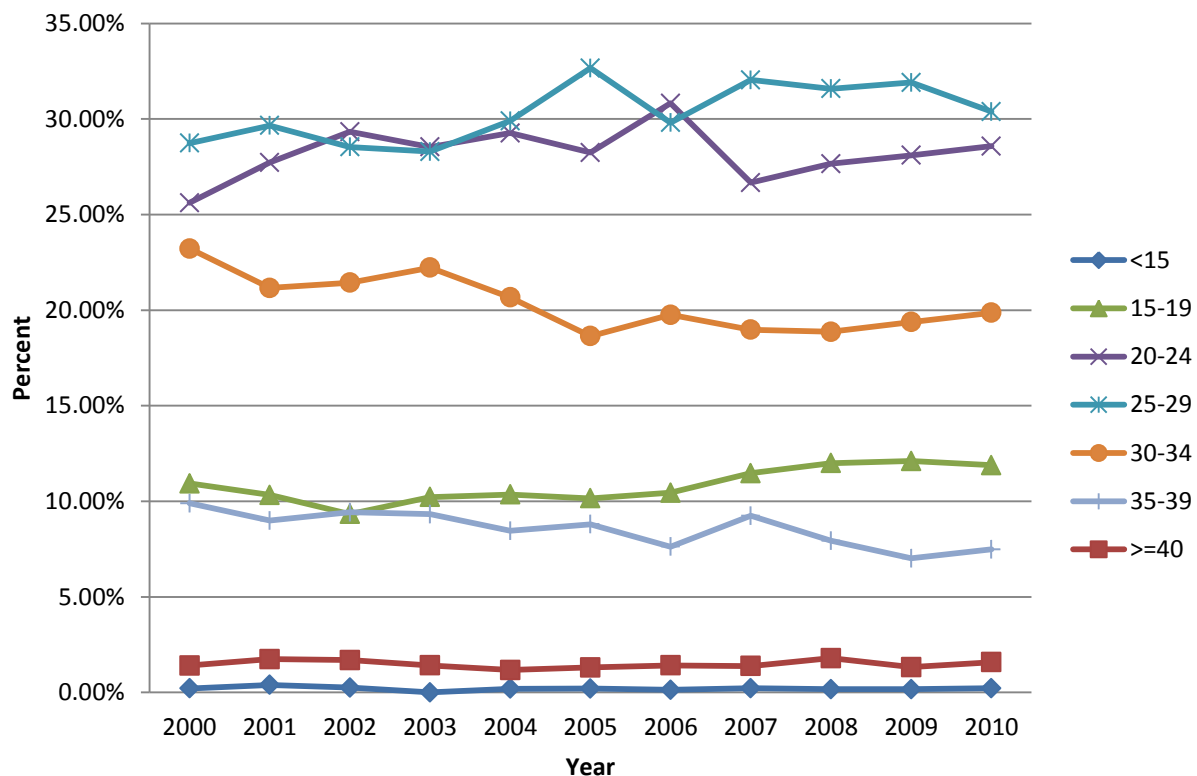


Figure 8. Distribution of the percent of women that had labor induced by age category in Montgomery County, Ohio from 2000 to 2010

The trend examining route of delivery in Montgomery County, shown in Figure 9, is very similar to the trend of labor. As exhibited by the graph, vaginal delivery has steadily declined over the 11 year span. Furthermore, birth by Cesarean section continues to rise. In 2000, nearly 80% of births occurred vaginally. Just 11 years later, only 68.83% of births in Montgomery County resulted from vaginal delivery. Similar to trends across the United States, Montgomery County experienced a significant (P -value $< .001$) increase in births by C-section; increasing 57% from 2000 to 2010 (19.91% to 31.17%).

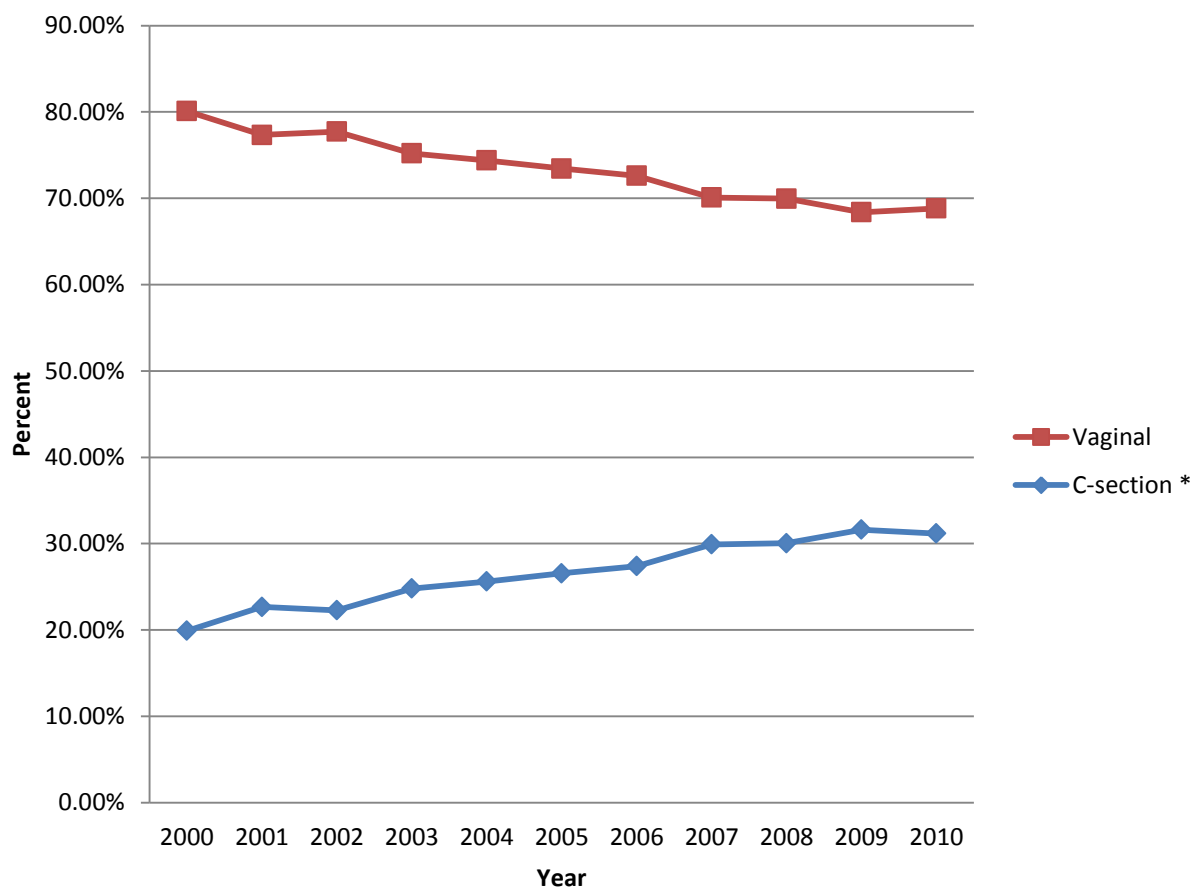


Figure 9. Route of delivery rates in Montgomery County, Ohio from 2000 to 2010

Note: * represents trend lines that were tested for significance

Figure 10 shows the distribution of the percentage of women that had C-section delivery by age category in Montgomery County, Ohio from 2000 to 2010. Most of the age categories have continued to fluctuate during the course of the study period, in essence remaining relatively stable from 2000 to 2010. One notable trend is the percentage of mothers between the ages of 25 and 29 that had a C-section delivery. This category has increased almost 12%, from 27.34% in 2000 to 30.53% in 2010.

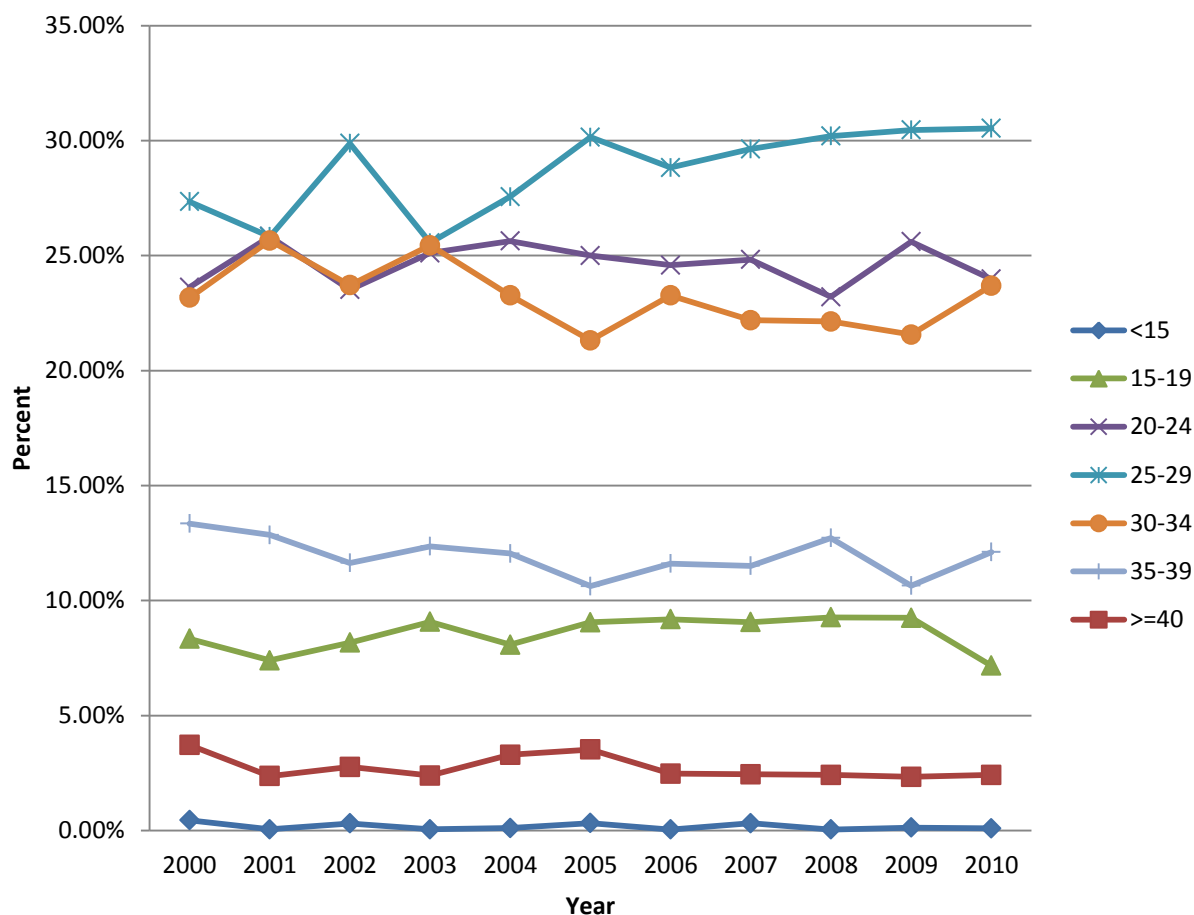


Figure 10. Distribution of the percent of women that had C-section delivery by age category in Montgomery County, Ohio from 2000 to 2010

Figure 11 displays the trends of the routes of delivery for mothers who had labor induced versus the routes of delivery for mothers who did not have labor induced. Similar to overall trends in the U.S., from 2000 to 2010 there was a significant ($P\text{-value} < .001$) decline in the percentage of vaginal births as a result of natural labor; a 28.6% drop, decreasing from 58.74% of all births to 41.93%. Furthermore, the rate of women having a C-section when labor is not induced increased from 16.71% in 2000 to 24.43% in 2010. The percentage of mothers having a C-section when labor was induced has steadily increased over 11 year period, increasing more than 110% (3.19 to 6.77%).

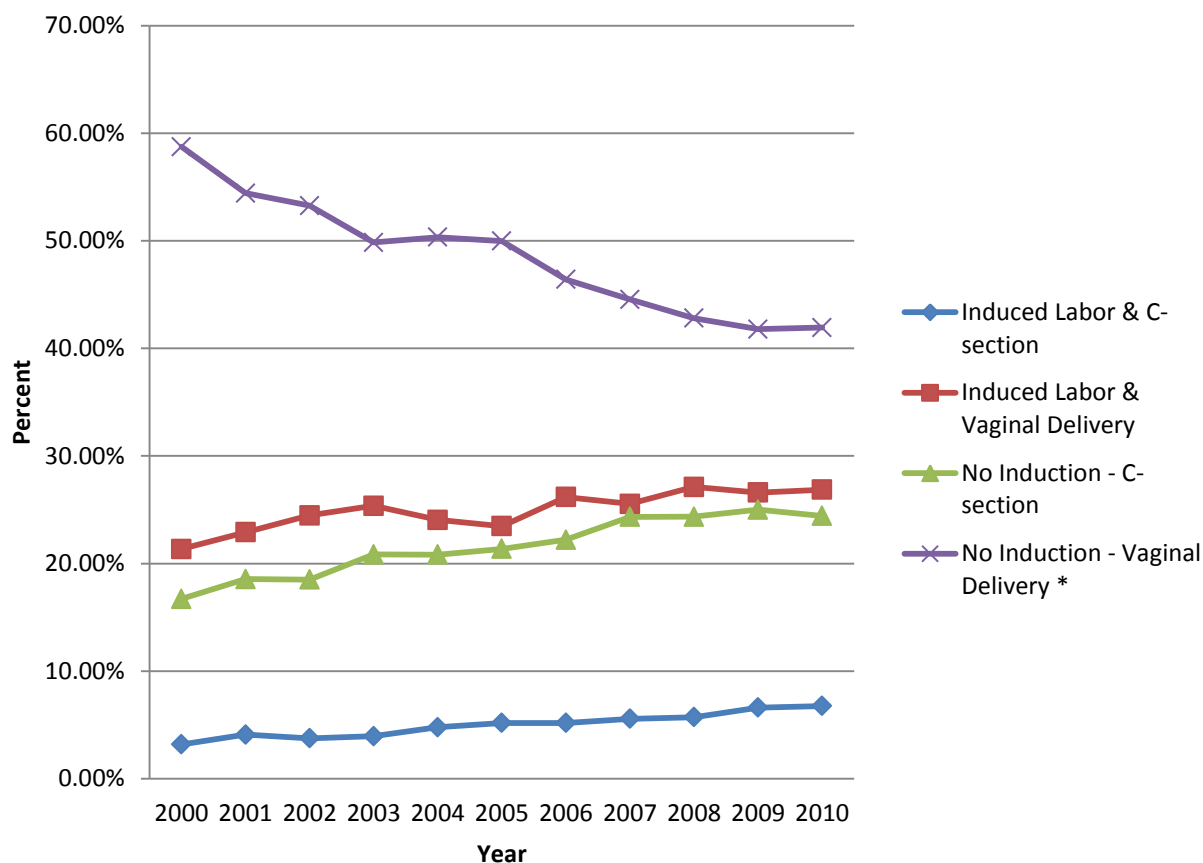


Figure 11. Distribution of labor processes and delivery processes for all births in Montgomery County, Ohio from 2000 to 2010

Note: * represents trend lines that were tested for significance

Examining trends for preterm, early term, full term, and post term gestational age in Figure 11 shows that overall gestational age in Montgomery County has fluctuated for the past 11 years. Preterm birth rates have remained relatively unchanged; preterm delivery increased slightly from 13.36% in 2000 to 13.5% in 2010. Post term delivery decreased to 5.68%, down from 7.69% in 2000. Full term rates continue to change with a three year increase from the lowest point in 2005 of 51.06% of all births to the high of 56.69% in 2008. Additionally, during this same time span there has been a notable decrease in early term births; from the high in 2008 for 30.24% of all births in Montgomery County down to 24.67% in 2010.

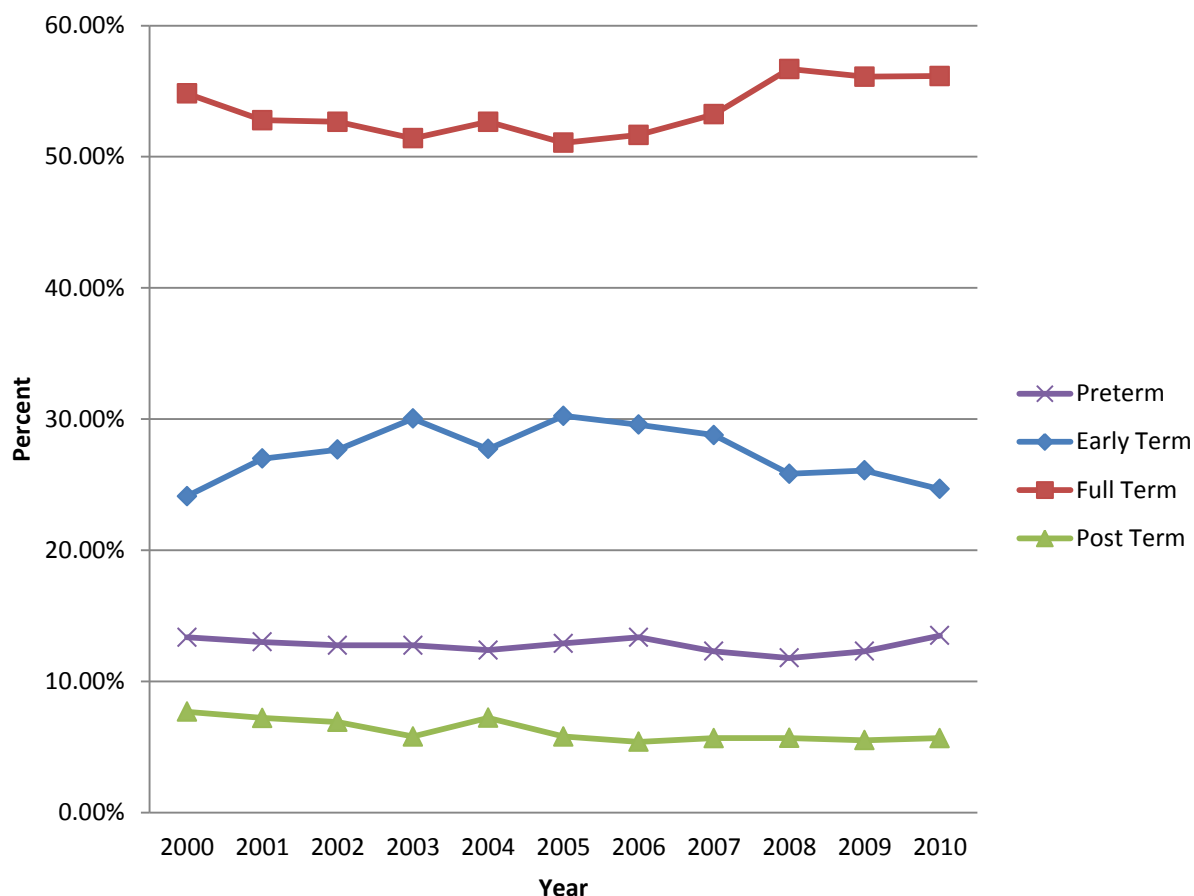


Figure 12. Gestational age distribution of babies born Montgomery County, Ohio from 2000 to 2010

The total percentage of preterm births reported in Montgomery County from 2000 to 2010 was broken down further to examine trends in early preterm birth and late preterm birth, shown in Figure 13. From these trends, it is evident that late preterm births contribute largely to the overall preterm birth rates. Though the trends have fluctuated over the past 11 years, from 2000 to 2010 the rates have changed only slightly. Still, it is important to note increases in both early preterm and late preterm births, resulting in an overall 15% increase for preterm births in Montgomery County over the past two years.

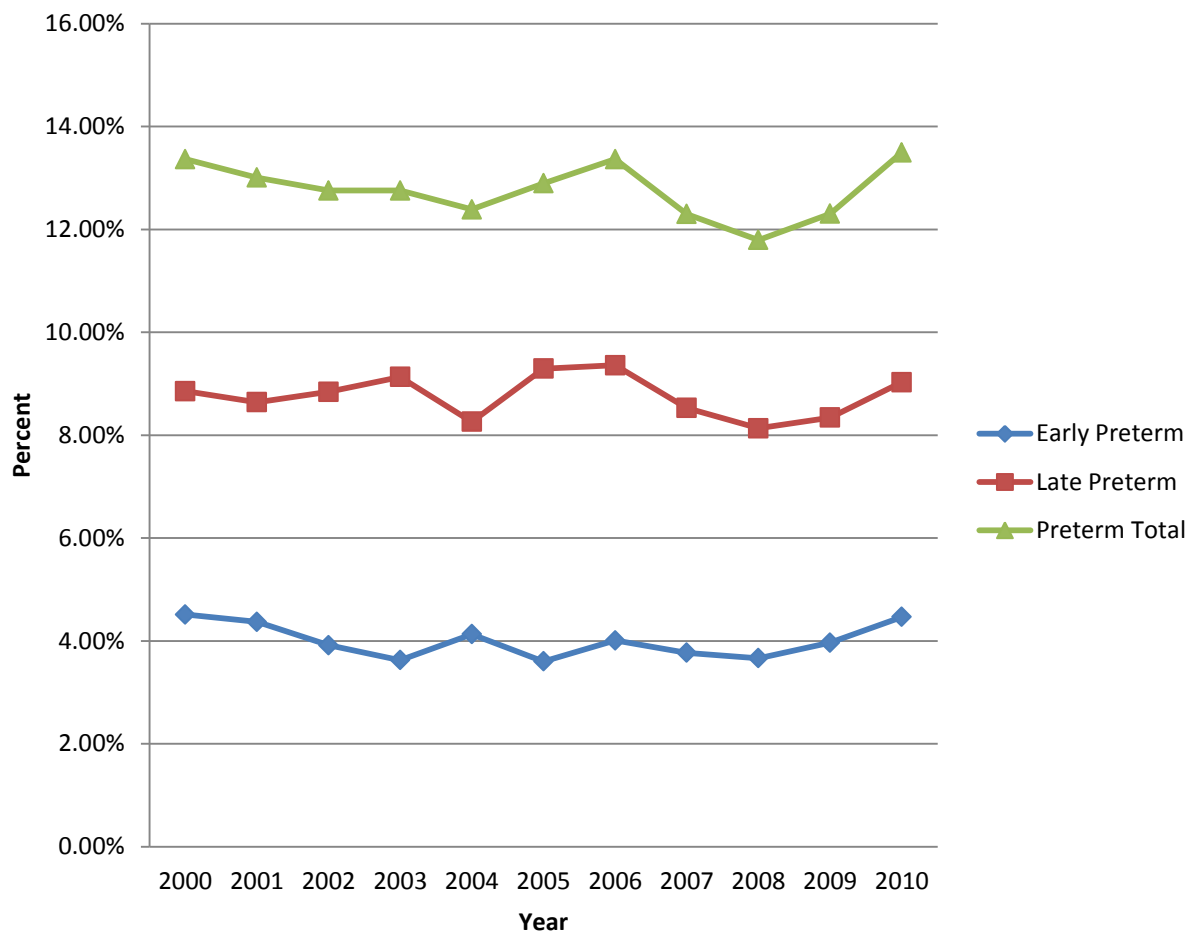


Figure 13. Total preterm birth distribution broken down by early preterm and late preterm births in Montgomery County, Ohio from 2000 to 2010

Figure 14 shows the distribution of the percentage of babies born in Montgomery County that fall into the following birthweight categories; very low birthweight, low birthweight, normal birthweight, and high birthweight. From 2000 to 2010 more than 80% of the infants born in Montgomery County have been within the normal birthweight range (2,500 to 4,000 grams). As evidenced by the graph, birthweight categories in Montgomery County over the past 11 years have remained fairly steady.

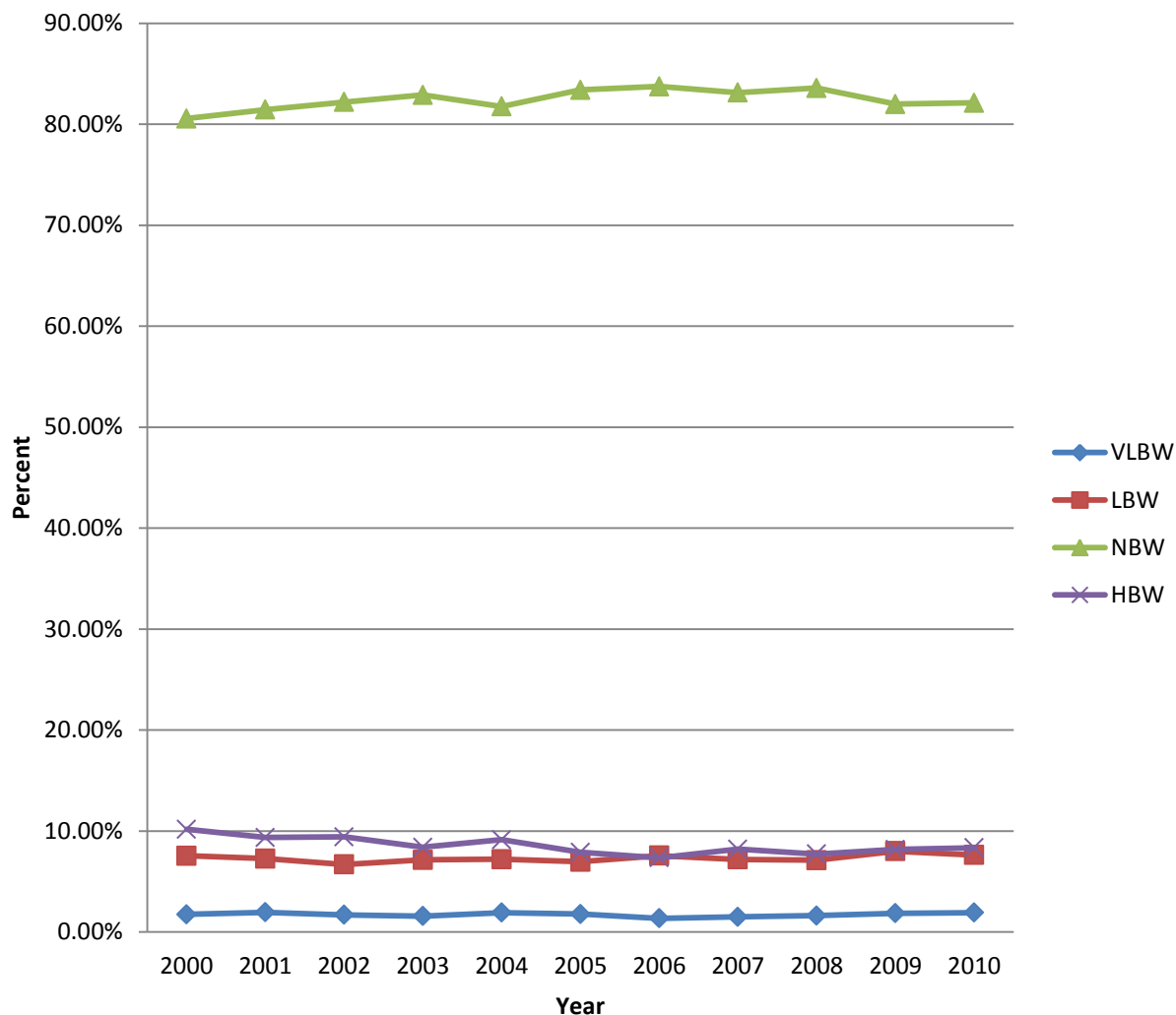


Figure 14. Distribution of babies born within each birthweight category in Montgomery County, Ohio from 2000 to 2010

Figure 15 shows the distribution of the percentage of infants in Montgomery County born with birthweights outside of the normal range. Though VLBW, LBW, and HBW babies make up less than 20% of infants, it is important to study these trends because of their association with morbidities. While HBW babies decreased, the percentage of both VLBW and LBW increased. The percentage of very low birthweight babies increased from 1.75% to 1.91% in 2010. Similarly, the percentage of low birthweight babies increased to 7.62%, up from 7.54% in 2000.

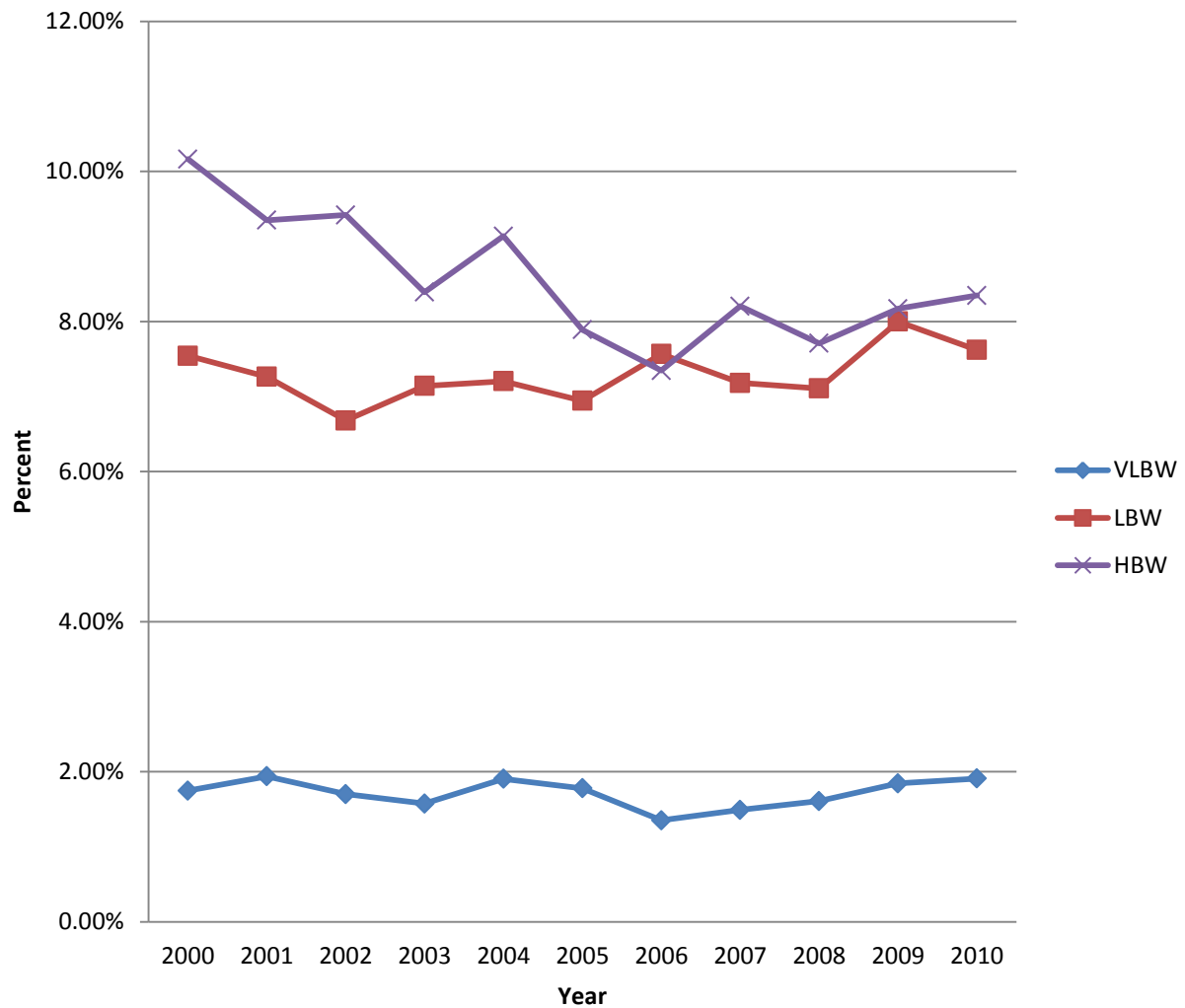


Figure 15. Trends in birthweight categories outside the normal range in Montgomery County, Ohio from 2000 to 2010

Table 4. *Comparison of the Trends Found in Montgomery County, Ohio and the Overall Trends in the United States*

Variable	Montgomery County Trend	United States Trend
Maternal Age	Ages 15-19 decreased 20% Ages 25-29 increased 10.4%	From 1991 to 2001 Ages 15-19 decreased 37% Ages 35-39 increased 36% Ages 40-44 increased 70% (Heffner, 2004; Martin et al., 2011)
Educational Attainment	The percentage of mothers who had: Some HS decreased 14% Associate's degree increased 16% Master's degree increased 18% Doctoral degree increased 50%	Increase in the percentage of women that finished high school (16%) and the percentage of women that attained a bachelor's (18%) (Jaysen, 2008)
<i>BMI</i>	Overweight and obese mothers make up 50% of the population	50% of singleton births in 2006 were by overweight or obese mothers (Kirmeyer & Rubertone, 2008)
Infertility Tx	Less than 2% of women used ART 46.5% increase from 2008 to 2010	More than 1% of infants are conceived using ART The number of births as a result of ART increased 2 times from 2000 to 2009 (CDC, 2009b)
GWG	50% of women gained above the recommendations	30-40% gain above or below the recommendations (Stotland et al., 2005)
<i>Labor Induction</i>	Labor induction rose 37%	125% increase from 1989 to 2001 and increased from 10% in 1990 to 22% in 2006 (Simpson & Atterbury, 2003; Martin et al., 2009a)
<i>C-section</i>	Increased 57%, from 19.91% in 2000 to 31.17% in 2010	Makes up 31% of all deliveries in the U.S. each year (O'Callaghan, 2010)
Gestational Age	3 year increase in preterm birth from 2008 to 2010	4 year decline in preterm birth from 2006 to 2010 (Hamilton et al., 2011)
Birthweight	HBW declined slightly	Increase in number of newborns weighing less than 3,500 grams (Martin et al., 2011)

In Table 4, Montgomery County trends of the maternal demographics, obstetric procedures, and infant outcomes that were examined in this study are compared to overall trends

in the United States. The variables that are colored red and italicized are factors for which trends in Montgomery County followed overall trends in the United States. These include pre-pregnancy BMI, induction rates, and C-section rates. Trends that differed include maternal age, educational attainment, infertility treatment use, gestational weight gain, gestational age, and birthweight.

Discussion

Many factors play a role in maternal and infant health and over the past 50 years these factors have changed drastically. Studies across the United States have examined the trends of maternal demographics, obstetric procedures, and birth outcomes. Accordingly, this study looked at a large variety of key factors which directly contribute to maternal and infant health. The trends found locally were then compared with overall trends in the United States. While some results were found to be similar to trends across the United States, not all were.

This study found a decrease in the percentage of mothers between the ages of 15 and 19 giving birth and an increase in the percentage of mothers between the ages of 25 and 34 giving birth in Montgomery County, Ohio from 2000 to 2010. Many studies in the United States which examined advancing maternal age have too found similar results. For example, Martin et al. (2011) found the birth rate for teenagers (15-19) fell 37% from 1991 to 2009. The shift to older mothers could be due to public health initiatives, such as Teen Pregnancy Prevention, that have worked to implement intervention plans to decrease the number of teen births and increase the number of women delaying childbearing (Maternal and Child Health, 2006). Results of the study also showed a decrease in the percentage of mothers that had only attained some high school and an increase in the percentage of mothers that had attained either an associate's degree or master's degree. Social norms have also played a role in this shift toward older, more

educated mothers further influencing women to delay childbearing and seek higher education. One study found that from 1970 to 2000, the percentage of women that finished high school and the percentage of women that earned a bachelor's degree increased 37% and 118%, respectively (Day & Newburger, 2002). The increase in the percentage of mothers receiving an associate's degree in Montgomery County, Ohio could be due, in part, to the number of surrounding institutions, such as Sinclair Community College and Kettering College of Medical Arts, which offer such a degree. Having close access to higher education may encourage women in Montgomery County, Ohio to hold off on making a family in order to pursue higher education.

Nearly half of the mothers that gave birth in Montgomery County from 2006 to 2010 were considered to be overweight or obese. Furthermore, this study saw a shift from overweight to obese mothers, as pre-pregnancy obesity increase 9.8% over the study period. The high percentage of pre-pregnancy overweight and obesity is most likely a response to the obesity epidemic, which has spread across the United States since the 1980s. Today, one in three adults is considered to be obese (CDC, 2011a). Obesity is a very complex problem which is enhanced by changes in the environment. Technology has no doubt led to a more sedentary lifestyle, where more people work desk jobs and on computers and then come home to play on social networking websites or watch television, leaving only a small amount of time for physical activity. This lifestyle, coupled with the evolving guidelines for gestational weight gain, could be why more than 50% of women in Montgomery County gained more than the recommended weight for their BMI category during gestation.

This study found that only a very small percentage of women in Montgomery Country utilized infertility treatments; representing fewer than 2% of the overall study population and remaining fairly constant over the five year span. Reports have shown that women between the

ages of 35 and 40 make up 41% of all women using infertility treatments in the United States, and women that are 41 years or older make up an additional 21% (CDC, 2011b). Infertility use in this study might not have seen a drastic increase, as shown in the United States, because the majority of mothers that gave birth were between 15 and 34 years of age. The percentage of mothers that are 35 years of age and older that gave birth accounted for less than 10% of all births in Montgomery County and mothers that are 35 years of age or older accounted for just over 5% of all first time births. Furthermore, infertility treatments are expensive and covered by only 25% of health care plans in the United States (Bitler & Schmidt, 2008). If, in the next several years, local advancing maternal age trends follow trends in the United States and these technologies become more affordable, we might see more utilization of infertility treatments.

This study found a significant increase in both induction rates and C-section rates and a significant decrease in non-induced vaginal delivery. While obstetric procedures are utilized to decrease health risks to both the mother and baby in some cases, elective induction and C-section have become more and more common in the past decade. This means that more women are effectively scheduling delivery versus waiting for the birthing process to occur naturally. From 1990 to 2006 induction rates in the United States rose 120% (Martin et al., 2009a) and elective induction continues to grow faster than induction as a whole (Caughey et al., 2009). Some studies suggest that there may be an over medicalization of childbirth, as it has become common in medical practice to induce labor for convenience of both the doctor and mother. C-section rates have too continued to rise over the past several years. In 2010, C-section delivery made up 31% of deliveries in Montgomery County and in the United States. Speculation has been made as to why this number has recently reached an all-time high. Advancing maternal age, obesity,

and defensive medicine are among the factors thought to contribute to this increase (Niino, 2011).

More than half of the babies born in Montgomery County, Ohio from 2000 to 2010 were full term births. Additionally, the results showed a three year increase in preterm births despite overall trends in the United States which have reported a four year decrease in preterm birth rates. A slight decrease in the percentage of post term births in Montgomery County was also found. This increase in preterm birth and decrease in post term birth are likely due to the increase in elective induction, C-section rates, and plural births over the past several years (Martin et al., 2011).

Although VLBW, LBW, and HBW babies made up 20% of the babies born in Montgomery County, Ohio from 2000 to 2010, this study found that the percentage of HBW babies decreased by 18%. Over the past 20 years, studies in the United States have shown an increase in the number of newborns weighing less than 3,500 grams. This shift toward lower birthweight babies, both in Montgomery County and in the United States, could be associated with shortened gestational age and increase in obstetric intervention (induction and C-section) over the past 30 years.

Limitations

Limitations are inherent with recorded birth certificate data. Though birth certificate data provides information to calculate birth statistics which cover the general population almost completely, some of the reported information may be unreliable. Previously, much of the information recorded in birth certificates was self-reported by the mother. For many reasons, such as limited recall or false reporting, this information may be inconsistent or go unreported altogether. Also, reporting may vary from person to person. The accuracy of birth certificate

data is a significant limitation in this study. Another notable limitation includes inconsistencies due to changes in birth certificate reporting in 2006; constricting the study period for many parameters to five years. Furthermore, data that was not reported had to be excluded from the study. Trends can be biased by changes in pregnancy care and medical technology improvements. This is enhanced by lack of timely reporting because results are often delayed. Reporting needs to be complete and consistent in order to minimize limitations which could hinder future examination of relevant factors associated with maternal and infant health.

Future research needs to further identify maternal conditions and complications which could lead to maternal and infant morbidities. Health surveillance also needs to include examination of factors associated with these conditions. Providing such information could influence both health policy and delivery of health services, ultimately improving maternal and infant health (Callaghan, MacKay, & Berg, 2008). In order to improve the quality of care and outcomes in pregnant woman and infants, it is essential to have timely vital statistics reports available. These systems and reporting mechanisms need to be standardized across counties, regions, states, and the country to allow for accurate data analysis.

Conclusion

The purpose of this study was to conduct analysis of Birth Certificate data for Montgomery County, Ohio. Due to changing social norms and advancing technology, it was hypothesized that trends in advancing maternal age, fertility treatment use, pre-pregnancy BMI, induction, and C-section rates would increase. Significant trends this study examined were increases in overall induction rates and overall C-section rates, and a decrease in non-induced women delivering vaginally. Trends found to be similar to those overall trends in the United States include maternal BMI, induction rates, and C-section rates. The disparities which effect

maternal and infant health likely vary from community to community and from state to state. For this reason, public health at all levels (local, state, national) need to identify and monitor these influential factors that could provide necessary information for successful interventions which promote optimal health outcomes. Improving the well-being of both mother and baby should remain a focus of public health across the United States and around the world.

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Appendix A – Additional Results

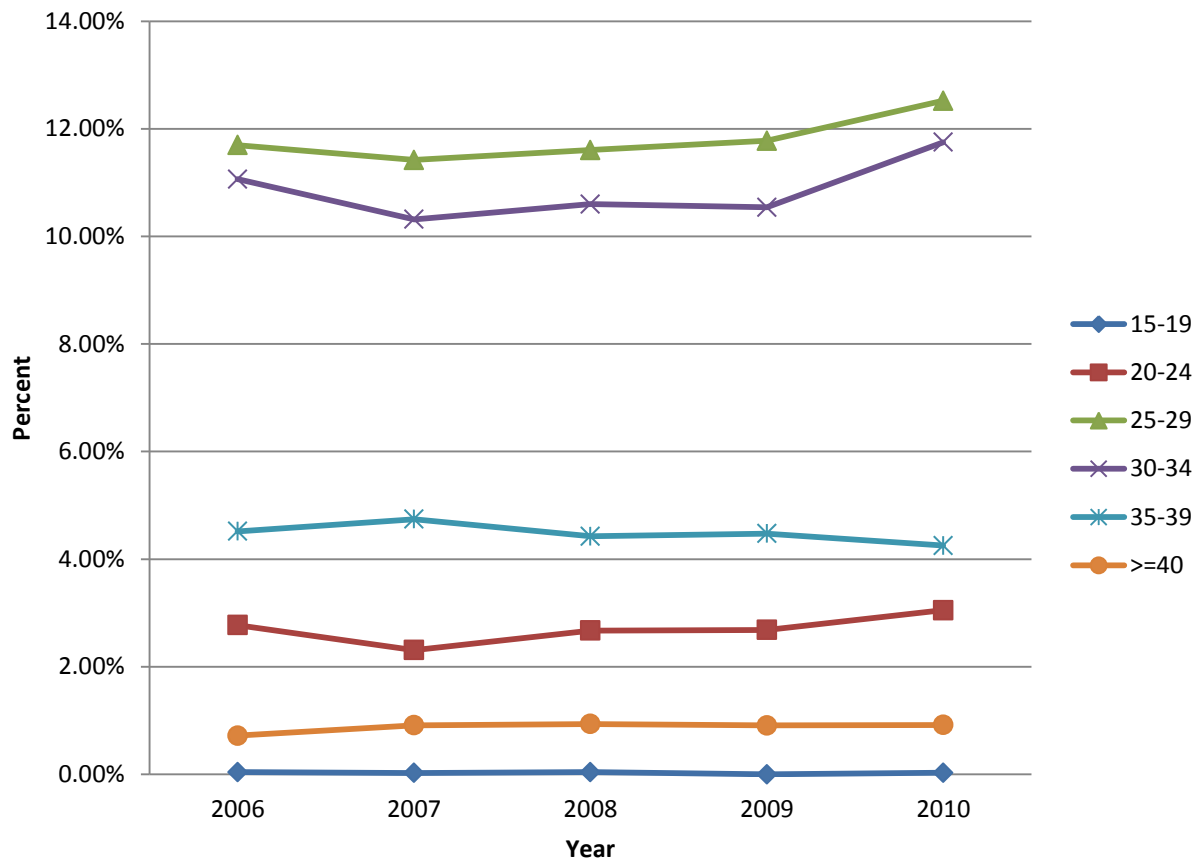


Figure 16. Distribution of percent of mothers that have attained a college degree (associate's degree, bachelor's degree, doctorate degree, or professional degree) by maternal age categories in Montgomery County from 2006 to 2010

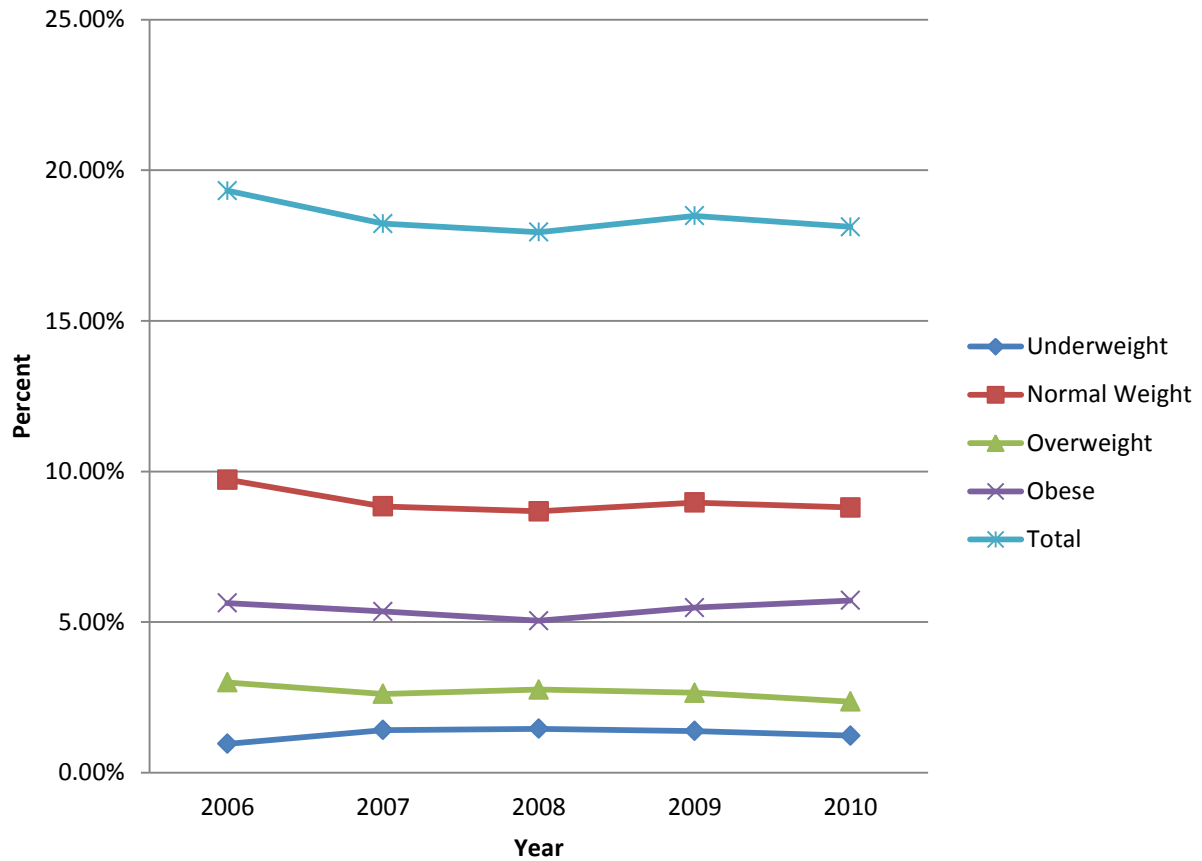


Figure 17. Distribution of the percent of women that gained below the IOM recommended gestational weight gain by BMI category in Montgomery County from 2006 to 2010

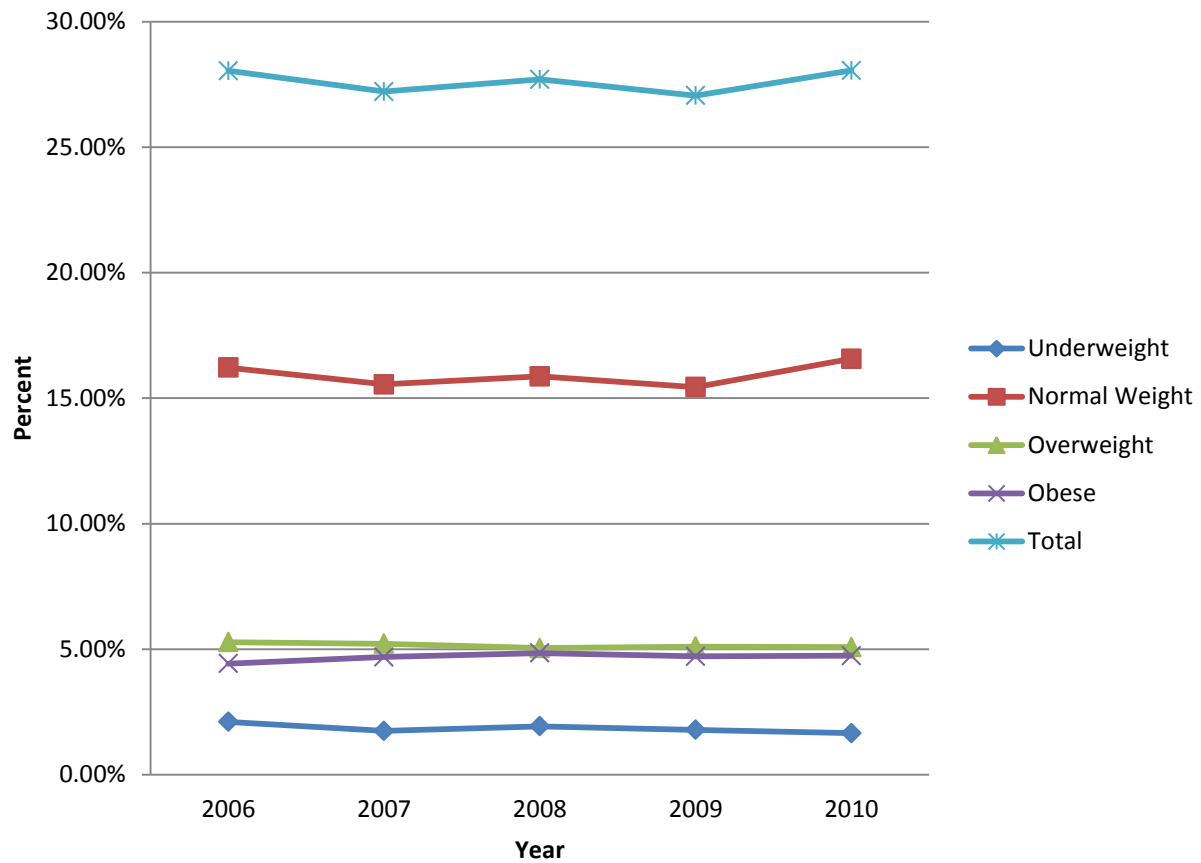


Figure 18. Distribution of the percent of women that gained within the IOM recommended gestational weight gain by BMI category in Montgomery County from 2006 to 2010

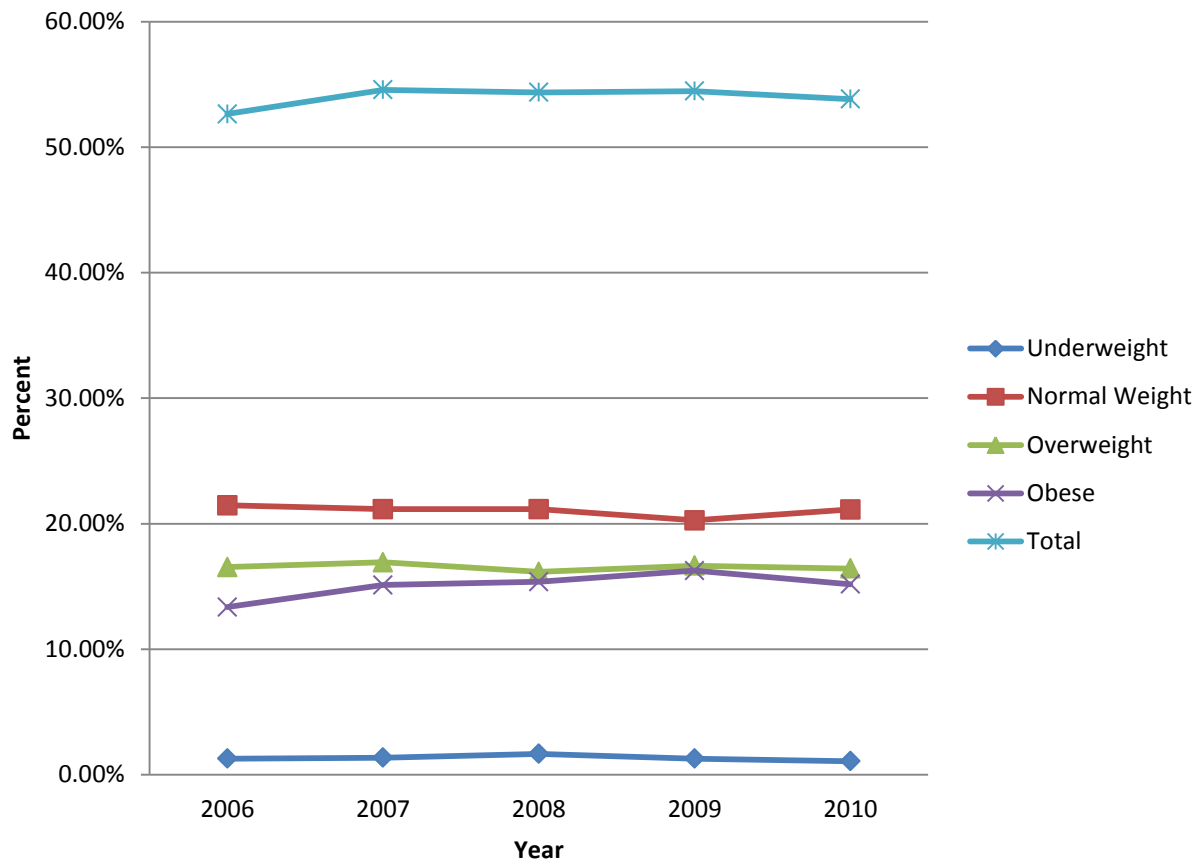


Figure 19. Distribution of the percent of women that gained above the IOM recommended gestational weight gain by BMI category in Montgomery County from 2006 to 2010

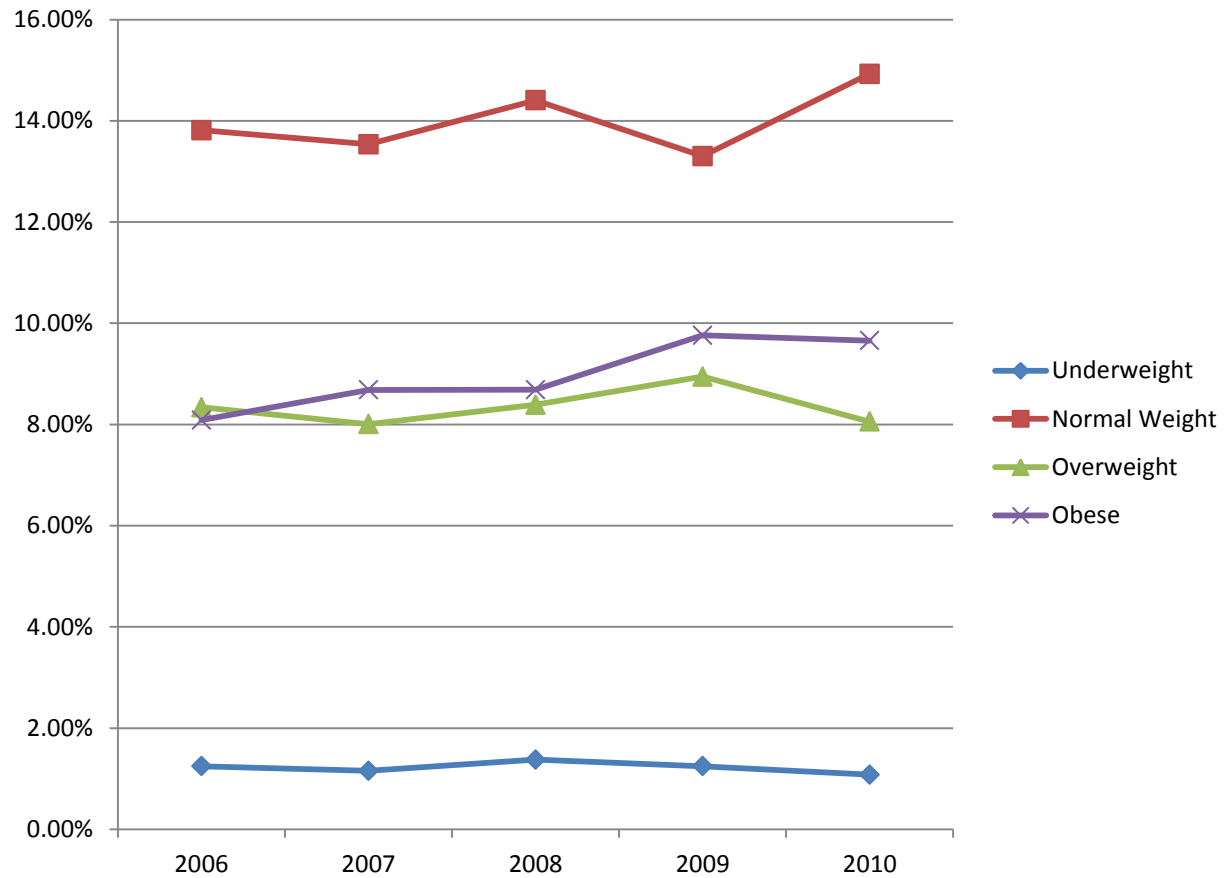


Figure 20. Distribution of the percent of women that had labor induced by BMI categories in Montgomery County from 2006 to 2010

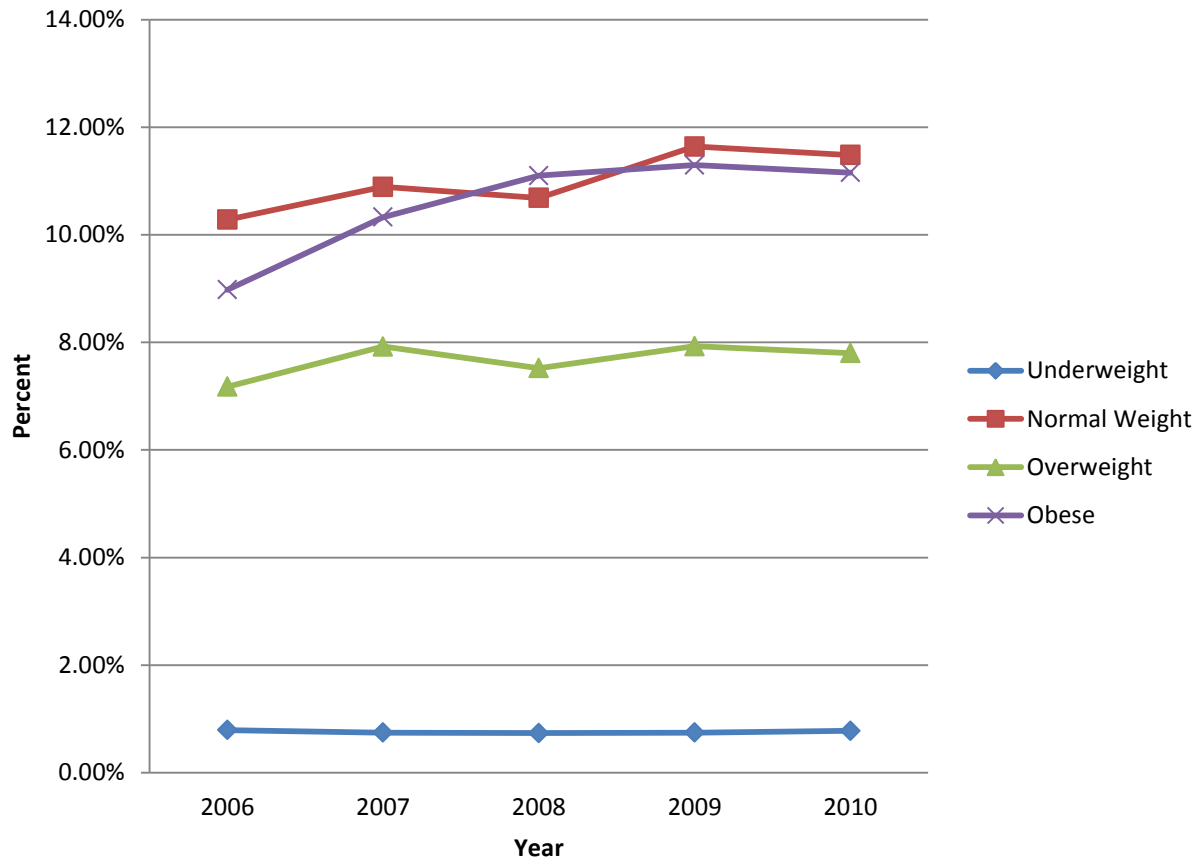


Figure 21. Distribution of the percent of women that had C-section deliveries by BMI category in Montgomery County from 2006 to 2010

Appendix B - Independent Review Board Letter of Approval (PHDMC)



Public Health
Prevent. Promote. Protect.

**Dayton &
Montgomery
County**

Reibold Building
117 South Main Street
Dayton, Ohio 45422
937-225-4479 Voice
937-224-8078 Fax

Health Commissioner
James W. Gross, M.P.H.

**Assistant to the
Health Commissioner**
Jeffrey A. Cooper, M.S.

Medical Director
Thomas Herchline, M.D.

**Director
of Disease Prevention**
Director of Nursing
Beatrice Harris, M.S., R.N.

Board of Health

President

J. Michael Sims

President—Elect

Jan Lapore-Jentleson

Karen A. Doggett, FMP, CFSP

Lloyd L. Laubach, Ph.D.

Gary L. LeRoy, M.D.

Patricia S. Meadows, MSSW

David Page, M.D.

John X. Valassilades, M.D.

*Equal Opportunity
Employer/Service Provider*



December 19, 2011

Abby Burns
8141 Starry Night Drive
Germantown, OH 45327

Dear Ms. Burns

IRB #: 2011.12.4.

Title of Proposal: Evaluation Demographic Changes in Maternal and Infant Health:
Tracking Trends and Correlations among Maternal Demographics, Delivery Processes
and Fetal Outcomes

The Public Health-Dayton & Montgomery County (PHDMC) Research Review Panel has reviewed and accepted your research project. You have been approved to conduct this study for one calendar year beginning December 19, 2011. Projects must be conducted in full accordance with the guidelines of Public Health-Dayton & Montgomery County (PHDMC).

Annually, **OR** when the project is completed, a project report must be submitted. For any research activity which continues beyond one year after the approval start date, project status reports will be requested by the PHDMC Research Review Panel. Any significant change in procedure, research participants, or plans to publish not addressed in the original project application must be reviewed and approved prior to implementation.

A confidentiality agreement must be signed by all research participants prior to the execution of any research activities. This agreement and any other signed documents will be kept by the PHDMC Research Review Panel for at least three years past completion of the research project.

Thank you for considering Public Health-Dayton & Montgomery County as an agency to assist you in your pursuit of scientific exploration. We look forward to working with you.

Sincerely,

James W. Gross, MPH
Health Commissioner


Appendix C - Independent Review Board Letter of Approval (WSU)



Office of Research and Sponsored Programs
201J University Hall
3640 Col. Glenn Hwy.
Dayton, OH 45435-0001
(937) 775-2425
(937) 775-3781 (FAX)
e-mail: rsp@wright.edu

DATE: November 1, 2011

TO: Abby N. Burns, P.I., Student
Public Health
Sara Paton, Ph.D., Fac. Adv.
Community Health

FROM: B. Laurel Elder, Chair 
WSU Institutional Review Board

SUBJECT: SC# 4626

'Demographic Changes in Maternal and Infant Health: Tracking Trends and Correlations among Maternal Demographics, Delivery Processes and Fetal Outcomes'

At the recommendation of the IRB Chair, your study referenced above has been recommended for exemption. Please note that any change in the protocol must be approved by the IRB; otherwise approval is terminated.

This action will be referred to the Full Institutional Review Board for ratification at their next scheduled meeting.

NOTE: This approval will automatically terminate two (2) years after the above date unless you submit a "continuing review" request (see http://www.wright.edu/rsp/IRB/CR_sc.doc) to RSP. You will not receive a notice from the IRB Office.

If you have any questions or require additional information, please call Robyn Wilks, IRB Coordinator at 775-4462.

Thank you!

Enclosure

RESEARCH INVOLVING HUMAN SUBJECTS

SC# 4626

ACTION OF THE WRIGHT STATE UNIVERSITY

EXPEDITED REVIEW

Assurance Number: FWA00002427

Title: 'Demographic Changes in Maternal and Infant Health: Tracking Trends and Correlations among Maternal Demographics, Delivery Processes and Fetal Outcomes'

Principal Investigator: Abby N. Burns, P.L. Student

Public Health

Sara Paton, Ph.D., Fac. Adv.

Community Health

The Institutional Review Board Chair has approved an exemption with regard to the use of human subjects on this proposed project.

REMINDER: Federal regulations require prompt reporting to the IRB of any changes in research activity [changes in approved research during the approval period may not be initiated without IRB review (submission of an amendment), except where necessary to eliminate apparent immediate hazards to subjects] and prompt reporting of any serious or on-going problems, including unanticipated adverse reactions to biologicals, drugs, radioisotope labeled drugs or medical devices.

P. Paul Elden Ph.D.

Signed

Chair, WSU-IRB

Approval Date: November 01, 2011

IRB Mtg. Date: November 21, 2011

ACTION OF THE WRIGHT STATE
UNIVERSITY
EXPEDITED REVIEW
Assurance Number: FWA00002427

DATE: January 26, 2012

TO: Abby N. Burns, P.I., Student

Sara Paton, Ph.D., Fac. Adv.

FROM: Bette Sydelko, MS.L.S. *BS*
Facilitator, Expedited Review Advisory Committee

SUBJECT: WSU Institutional Review Board
Administrative Approval RE: Abby N. Burns, P.I., Student
SC# 4626 #1

'Demographic Changes in Maternal and Infant Health: Tracking Trends and Correlations among Maternal Demographics, Delivery Processes and Fetal Outcomes'

This amendment was approved by RSP per Board Policy of May, 1994. This amendment does not contain significant changes nor does it impact on subject treatment/care. This amendment resulted from:

- | | |
|--|---|
| <input type="checkbox"/> Team Member Change | <input type="checkbox"/> Question Addition |
| <input checked="" type="checkbox"/> Procedure Addition | <input type="checkbox"/> Material/Strategy Change |
| <input type="checkbox"/> Procedure Removal | <input type="checkbox"/> Minor Correction |

Comments:

Administrative approval was given for the following. Since the approval of the initial IRB petition, the 2010 Ohio Natality Statistical Files collected by the Ohio Department of Health Center for Vital Statistics has become available. The PI has been granted approval to use 1999-2009 data and would like to incorporate the most recent data set, 2010 into her research. Per request dated 1/18/12 from A. Burns.

The Board will be notified of this action at the next regularly scheduled meeting.



**Wright State University IRB
Modification/Amendment Request**

Date: 1/18/2012	WSU HSP/SC# 4626	Amend #1 (Admin)
Principal Investigator: Abby Burns	Phone: 937-286-4612	E-mail: Burns.107@wright.edu
Title of Research Project: Demographic Changes in Maternal and Infant health: Tracking Trends and Correlations among Maternal Demographics, Delivery Processes, and Fetal Outcomes		

1. Is the sponsor initiating the proposed amendment? ☐ Yes ☒ No

If yes, provide the amendment number

2. Mark all that apply:

☐ Administrative change (check appropriate box(es) from following list):

- ☐ Addition or deletion of study team members
- ☐ Addition of procedures that do not significantly increase risk to subjects
- ☐ Removal of research procedures resulting in a reduction in risk to subjects
- ☐ Addition of nonsensitive questions to unvalidated survey or interview procedure
- ☐ Addition of or revisions to recruitment materials or strategies
- ☐ Administrative changes (e.g. correction of spelling, grammar or typographical errors) to approved documents

☒ Protocol revision(s)

☐ Consent form revision(s)

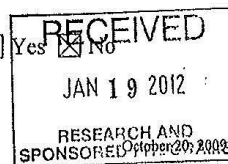
☐ Other (specify)

3. Describe modification/amendment (use/attach additional pages if necessary):

Since the approval of the initial IRB petition, the 2010 Ohio Natality Statistical Files collected by the Ohio Department of Health Center for Vital and Health Statistics became available. Currently, I have been granted approval to use 1999-2009 data and would like to incorporate the most recent data set, 2010, into my research.

4. Will there be any increased risk, discomfort or inconvenience to the subjects? ☐ Yes ☒ No

If yes, provide detailed explanation and justification as an attachment



Appendix D - CITI Program Course Certificate

/14/12

Completion Report

CITI Collaborative Institutional Training Initiative**Human Research Curriculum Completion Report****Printed on 3/14/2012****Learner:** Abby Burns (username: AbbyNBurns)**Institution:** Wright State University**Contact Information** Phone: 937-258-5542

Email: Burns.107@wright.edu

Biomedical Research Investigators:**Stage 1. Basic Course Passed on 10/26/11 (Ref # 6933800)**

Required Modules	Date Completed	Score
Introduction	10/26/11	no quiz
Belmont Report and CITI Course Introduction	10/26/11	3/3 (100%)
History and Ethical Principles	10/26/11	6/6 (100%)
Basic Institutional Review Board (IRB) Regulations and Review Process	10/26/11	5/5 (100%)
Informed Consent	10/26/11	3/4 (75%)
Social and Behavioral Research for Biomedical Researchers	10/26/11	4/4 (100%)
Records-Based Research	10/26/11	2/2 (100%)
Genetic Research in Human Populations	10/26/11	1/2 (50%)
Research With Protected Populations - Vulnerable Subjects: An Overview	10/26/11	4/4 (100%)
Vulnerable Subjects - Research Involving Prisoners	10/26/11	3/4 (75%)
Vulnerable Subjects - Research Involving Children	10/26/11	3/3 (100%)
Vulnerable Subjects - Research Involving Pregnant Women, Human Fetuses, and Neonates	10/26/11	3/3 (100%)
International Studies	10/26/11	1/1 (100%)
Avoiding Group Harms: U.S. Research Perspectives	10/26/11	3/3 (100%)
FDA-Regulated Research	10/26/11	5/5 (100%)
Research and HIPAA Privacy Protections	10/26/11	4/5 (80%)
Vulnerable Subjects - Research Involving Workers/Employees	10/26/11	4/4 (100%)
Conflicts of Interest in Research Involving Human Subjects	10/26/11	5/5 (100%)
Wright State University	10/26/11	no quiz

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered

/14/12

Completion Report

scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

[Return](#)

Appendix E – Public Health Competencies Met

Specific Competencies
Domain #1: Analytic Assessment Skill
Defines a problems
Determines appropriate uses and limitations of both quantitative and qualitative data
Selects and defines variables relevant to defined public health problems
Identifies relevant and appropriate data and information sources
Evaluates the integrity and comparability of data and identifies gaps in data sources
Applies ethical principles to the collection, maintenance, use, and dissemination of data and information
Makes relevant inferences from quantitative and qualitative data
Obtains and interprets information regarding risks and benefits to the community
Applies data collection processes, information technology applications, and computer systems storage/retrieval strategies
Recognizes how the data illuminates ethical, political, scientific, economic, and overall public health issues
Domain #2: Policy Development/Program Planning Skills
Collects, summarizes, and interprets information relevant to an issue
Utilizes current techniques in decision analysis and health planning
Domain #3: Communication Skills
Communicates effectively both in writing and orally, or in other ways
Solicits input from individuals and organizations
Uses the media, advanced technologies, and community networks to communicate information
Effectively presents accurate demographic, statistical, programmatic, and scientific information for professional and lay audiences
Attitudes
Listens to others in an unbiased manner, respects points of view of others, and promotes the expression of diverse opinions and perspectives
Domain #4: Cultural Competency Skills
Identifies the role of cultural, social, and behavioral factors in determining the delivery of public health services
Attitudes
Understands the dynamic forces contributing to cultural diversity
Domain #5: Community Dimensions of Practice Skills
Develops, implements, and evaluates a community public health assessment
Describes the role of government in the delivery of community health services

Specific Competencies
Domain #6: Basic Public Health Sciences Skills
Defines, assesses, and understands the health status of populations, determinants of health and illness, factors contributing to health promotion and disease prevention, and factors influencing the use of health services
Understands the historical development, structure, and interaction of public health and health care systems
Identifies and applies basic research methods used in public health
Applies the basic public health sciences including behavioral and social sciences, biostatistics, epidemiology, environmental public health, and prevention of chronic and infectious diseases and injuries
Identifies and retrieves current relevant scientific evidence
Identifies the limitations of research and the importance of observations and interrelationships
Attitudes
Develops a lifelong commitment to rigorous critical thinking
Domain #7: Financial Planning and Management Skills
Manages information systems for collection, retrieval, and use of data for decision-making
Domain #8: Leadership and Systems Thinking Skills
Helps create key values and shared vision and uses these principles to guide action
Identifies internal and external issues that may impact delivery of essential public health services (i.e. strategic planning)